THE INSTITUTE OF PHYSICS

BULLETIN

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THE INSTITUTE OF PHYSICS

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47 BELGRAVE SQUARE, LONDON, S.W.1. TELEPHONE : BELGRAVIA 6111-2-3

Appointments Vacant

The inclusion of particulars of a vacancy must not be taken to imply that the Institute necessarily approves of the terms offered or that might be offered. Candidates should satisfy themselves that these are satisfactory, and they may always refer to the Institute for advice.

IMPERIAL COLLEGE PHYSICS DEPARTMENT

Applications are invited for posts of RESEARCH ASSISTANTS (Academic) to take part in research in the field of vacuum physics and photoelectronics applied to nuclear physics, astronomy, etc. A good degree essential and some research experience preferable. Appointees would be eligible to proceed to research degrees and would be considered later for permanent appointments. Salaries in the range £650 – £1,000 per annum, with superannuation, depending on qualifications. Applications with full academic and personal details and names of two referees must be sent to Professor J. D. McGee, Imperial College, London, S.W.7.

UNIVERSITY OF READING

Applications are invited from persons of Ph.D. standard for I.C.I. Research Fellowships in chemistry, physiological chemistry, agricultural chemistry, agricultural botany, microbiology, geology, physics or related subjects to which some appointments may be made during the current academic year. The appointments will normally date from October 1, 1959. Salary, depending on qualifications and experience, within the range £700 – £1,000 p.a., with F.S.S.U. benefits and family allowances. Applications (eight copies) with a list of publications and names of two referees, should be sent, not later than March 30, 1959, to the Registrar (Room 22, O.R.B.), The University, Reading, from whom further particulars may be obtained.

LEEDS COLLEGE OF TECHNOLOGY

COOKRIDGE STREET, LEEDS, 2

Principal :
C. CHEW, M.Sc.Tech., F.R.I.C.

ASSISTANT LECTURER Grade B in physics required to teach the subject up to O.N.C. standard. Applicants should have a good degree or equivalent qualification. Good industrial experience and some teaching experience is desirable.
The duties for the post to commence on September 1, 1959.
Salary in accordance with the Burnham Technical Scale : for a man £682 10s. 0d. – £26 5s. 0d. – £1,076 5s. 0d. per annum, and for a woman £609 0s. 0d.– £21 0s. 0d. – £861 0s. 0d. per annum, plus equal pay instalments.
Full allowance made for qualifications, training and previous experience.
Further particulars and form of application, to be returned by February 21, 1959, may be obtained by sending a stamped addressed foolscap envelope to the Principal of the College.

George Taylor,
Chief Education Officer.

THE UNIVERSITY OF ALBERTA,

Department of Physics, invites applications for the position of COSMIC RAY PHYSICIST, at the level of Assistant Professor, effective September 1, 1959. Applicants must have a Ph.D. degree with post-doctoral research experience. An established mountain observatory at Banff, Alberta, offers facilities for research work.
Initial salary will range from $7,000, according to qualifications and experience. A removal grant is normally made for married persons.
Applications for this position should include a *curriculum vitae*, transcripts of record, a recent photograph and the names of three references.
Applications and testimonials should be sent to : Professor H. Grayson-Smith, Department of Physics, University of Alberta, Edmonton, Canada.

A.E.R.E., HARWELL REACTOR SCHOOL

At the school Graduate Physicists and Engineers are given lectures on reactor theory and engineering and on associated subjects. An Assistant is required to set up and demonstrate physics experiments and to conduct students around the establishment.
Knowledge of experimental facilities and H.N.C., good G.C.E. "A" levels, or equivalent required ; experience with electronic equipment desirable.
Salary : £480 (at age 20) – £855.
Please send a postcard to the Group Recruitment Officer, (1282/110), U.K.A.E.A., Atomic Energy Research Establishment, Harwell, Berks., for details.

ESSEX COLLEGE

ASSUMPTION UNIVERSITY OF WINDSOR, WINDSOR, ONTARIO

The Department of Physics announces the following vacancies which have been created because of the expansion of the Department.

2 PHYSICISTS
1 APPLIED PHYSICIST OR ENGINEERING PHYSICIST

The duties will involve instruction in undergraduate and graduate courses in pure and applied physics. The successful applicants will also be expected to devote some time to research and may have the opportunity to initiate research in their fields. The rank and salary for each appointment will depend on qualifications and experience, but the salary will not be less than $5,500 at the Ph.D. level. Enquiries should be addressed to the Chairman of the Staff Committee, Essex College, Assumption University of Windsor, Windsor, Ontario, Canada.

ENGINEERS AND PHYSICISTS

The National Research Development Corporation is sponsoring a program of work at the Shirley Institute, Manchester, on the application of automatic control systems to spinning and similar textile processes. Applications are invited from physicists and electrical and mechanical engineers to join the team working on this program which is expected to lead to important developments in an old established industry. Academic or professional qualifications are essential, and some industrial experience is desirable. The work offers an interesting combination of academic and industrial research, and there will be ample opportunity for publication. At least one senior post is available. Starting salary within the range £700 to £1,250 (up to £1,400 for the senior post), plus superannuation benefit under F.S.S.U. Applications should be addressed to The Director, The Shirley Institute, Manchester 20.

UNIVERSITY OF GLASGOW

I.C.I. RESEARCH FELLOWSHIPS

Applications are invited for I.C.I. Research Fellowships in biochemistry, chemistry, engineering, pharmacology, or physics to which some appointments may be made during the current academic year. The appointments will date from October 1, 1959. The Fellows will hold the status of Lecturers in the University. The salary will depend upon qualifications and experience, but will be within the range £700 to £1,000 per annum, together with F.S.S.U. benefits and family allowances. Applications (eight copies), with a list of publications and names of two referees, should be sent not later than February 28, 1959, to the undersigned, from whom further particulars may be obtained.

ROBT. T. HUTCHESON,
Secretary of University Court.

THE COLLEGE OF AERONAUTICS

METALLURGIST OR PHYSICIST required as DEMONSTRATOR in the Department of Aircraft Materials to assist in experimental work and in laboratory teaching. An appropriate qualification, with relevant experience, is essential. Research is encouraged, and subsequent promotion to the Lecturer grade is possible for those suitably qualified. Consideration will be given to housing requirements. Salary within the scale £600 × £25 to £1,000 p.a. with superannuation under F.S.S.U. and family allowance. Applications giving full particulars of qualifications and experience and quoting names of three referees, to the Recorder, The College of Aeronautics, Cranfield, Bletchley, Bucks. Further particulars available.

SOUTH AFRICAN COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

A

PHYSICAL CHEMIST

with honours degree in chemistry and preferably a few years' experience of applied research required for the National Institute for Road Research, Pretoria.

The work will involve investigation of the different problems associated with the materials used for bituminous binders, the adhesion of tars and bitumens to roadstone and the oxidation of tars and bitumens.

Salary in range £700 – £1,320. Passages paid.

Apply further information:
South African Scientific Liaison Office,
Africa House, Kingsway,
London, W.C.2

CENTRAL ELECTRICITY GENERATING BOARD
NUCLEAR OPERATIONS BRANCH

Applications are invited for the following appointments at the Board's Headquarters, Bankside House, London, S.E.1.

A. OPERATION PHYSICIST

This is a senior post and the successful candidate will be responsible for the reactor physics of commissioning and operation for the Board's nuclear power stations. This work will include investigation into the economics and technical feasibilities of fuel cycles and the application of them to the Board's stations.
Whilst experience of nuclear reactors is not necessary, it is essential that candidates should have had a good theoretical background in physics or mathematics. Candidates should preferably have a higher degree and must be able to apply their theoretical knowledge to practical cases.

B. OPERATION SERVICES ENGINEER

This is a senior post and the successful candidate will be responsible for co-ordinating the commissioning, operation, maintenance and staffing of the Board's nuclear power stations.
Candidates should preferably possess a university degree in engineering and be corporate members of a senior Engineering Institution. They should have good experience of commissioning and operation of conventional power stations or other heavy mechanical or chemical plant.

C. PHYSICISTS AND ENGINEERS

A small team of Physicists and Engineers is required and the successful candidates will assist in the work carried out by the Operation Physicist and Operational Services Engineer.
Candidates for appointment to the Physics Section should have a university degree in physics or mathematics. Experience of nuclear reactors is not essential as any necessary training will be given.
Candidates for appointment to the Engineering Section should preferably have a university degree in engineering or be corporate members of a senior Engineering Institution. They should have similar experience to that required for the Operational Services Engineer, although at a less senior level.

Salaries :—
Posts "A" and "B" within provisional range £2,160 – £2,360 p.a.
Post "C" on scales within the range £1,435 – £2,005 p.a. according to duties and responsibilities.
Applications stating age, qualifications, experience, present position and salary, should be forwarded to S. S. Scott, Chief Personnel Officer, 24-30 Holborn, London, E.C.1, by February 28, 1959. Please mark envelope "Confidential Ref. PB/5."

PHYSICISTS required at the Research Laboratories, Leatherhead, Surrey, for research on X-ray diffraction and electron techniques, temperature measurement of materials and gases, atmospheric pollution, non-destructive testing, and meteorology as applied to conventional and nuclear power stations.
There is now an urgent need to expand work on nucleonic instruments and health physics measurements, and experience in these or related fields will be an advantage. In certain cases a period of training may be arranged.
Candidates should have an honours degree or equivalent qualification.
Salaries on scales within the overall ranges £1,160 – £1,735 p.a. and £550 – £1,265 p.a. according to duties and responsibilities. Ref. PB/6.

ASSISTANT ENGINEERS required at the Research Laboratories, Leatherhead, Surrey, to work on problems associated with conventional and nuclear power stations. Present investigations concern heat transfer in nuclear fuel elements and heat exchangers, electrostatic precipitators, cooling towers, and boiler feed pumps.
Candidates for senior vacancies should have an honours degree with previous research experience : for other vacancies a pass degree or H.N.C. with appropriate experience would be acceptable, but importance is attached to ability to apply fundamental knowledge.
Salaries on scales within the overall ranges £1,195 – £1,775 p.a. and £570 – £1,300 p.a., according to duties and responsibilities. Ref. PB/11.

Application forms obtainable from I. G. Ellis, Personnel Officer, 24-30 Holborn, London, E.C.1, should be completed and returned by February 28, 1959. Envelopes should be marked "Confidential" quoting reference.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH.

PRINCIPAL SCIENTIFIC OFFICER.

Pensionable post for Engineer or Physicist at least 31 on 1.1.59 at Mechanical Engineering Research Laboratory, East Kilbride, Glasgow, to lead team carrying out research on heat transfer in a new laboratory with exceptional facilities. Qualifications normally 1st or 2nd class honours degree in an appropriate subject or high professional attainment. Sound knowledge of basic principles of experimental techniques and of heat transfer and fluid mechanics necessary. Industrial experience in design or testing of heat-exchange equipment desirable. Salary scale (men) £1,370 – £1,950. Starting pay may be above minimum. Good housing prospects. Write Civil Service Commission, 17 North Audley Street, London, W.1, for application form, quoting S4926/59/14. Closing date March 18, 1959.

PHYSICIST for development work on Ammonia Masers. Original work is now needed and provides an outstanding opportunity for a man with ability and drive. A good degree plus experience in vacuum physics and instrument development is essential. Salary at least £1,200 p.a. Write giving particulars to Glass Developments Ltd., Sudbourne Road, S.W.2.

THE INSTITUTE OF PHYSICS

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Presenting Science on Television *

By ARTHUR GARRATT, M.B.E., B.Sc., A.Inst.P.

(Science Director, International Scientific Research Exhibitions Ltd.)

THE use of scientific material for television programs can be considered from three points of view. The first two are fairly obvious, viz. as a means of education and as entertainment. The third, which has not yet been exploited to any extent, may well prove the most important use for the scientists. This is the utilization of the medium to collect scientific data from a large fraction of the total population of the country.

Television in the last decade has increased its influence at a prodigious rate. At the end of 1947 the number of television licences was 14,859. The million mark was reached in October, 1951, and at the end of November, 1958, the figure had reached 8,571,491 and was still growing.(1) The B.B.C. Audience Research Department estimated that, at the end of 1957, the number of *adults* aged 16 and over in homes with television sets was 21,850,000, or 57·9 per cent of the total adult population of the country. The B.B.C. estimate, probably conservatively, that the number of television licences will rise from the present figure of 8½ million to 12 million in 1962.

It is interesting to trace the history of television in terms of the social class of viewers. In 1947 the television public was not by any means a representative cross-section of the public, it was weighted heavily in favour of the upper income groups. The upper 12 per cent of the population owned nearly half the sets while the bottom 68 per cent had only a quarter of the total. By the end of 1951 the position had reversed and the working class audience rose to 60 per cent of the total although the proportion of working class viewers was still much lower than the middle class. The present figures show that we can now regard the television audience as fully representative of social class. The middle classes, 24 per cent of adults, have 64 per cent of their numbers as viewers while the working classes have 58 per cent. These figures are equally representative of occupation and education.(2)

In terms of a given program, a popular feature may have a regular audience of 12 million—25 per cent of the total population. Talking to 100 people every day, it would take 400 years to address as many people as one can in a single program. This is the incredible medium of propaganda that science has given to the world —the ability to go into half the homes in the country and show the world to people by their own firesides. It behoves us scientists to use our gift to the world for the betterment of science.

WHAT CAN TELEVISION OFFER ?

Apart from the ability to address a vast audience at one and the same time, television has other advantages over a lecture. Because of its vast audience the economics are totally different and television can afford to spend quite large sums of money to obtain information and to get special effects. Two examples of this can be quoted from a recent scientific series, " New Horizon," presented by Associated-Rediffusion Ltd. For one program a full-sized distorted room as originally built by Ames at the Hanover Institute, New Hampshire, was constructed in the studio.(3) This has since been presented to the Psychology Department of a London college for teaching and research. Another program dealing with the statistical aspect of modern physics showed film of low temperature phenomena which was in a different class from the pictorial point of view than any previously available. Shot at the Mond Laboratory, Cambridge, and the Clarendon Laboratory, Oxford, with all the " know-how " of the professional cinematographer, the visual impact of this film was quite extraordinary. Superfluidity of liquid helium II was shown by suspending a small test-tube in a double dewar surrounded by liquid nitrogen which was continuously pumped to avoid ebullition bubbles. The helium dripped from the bottom of the tube and special lighting methods were used to make the drops, whose refractive index is almost exactly unity, readily visible. The film was shot at three frames every fifteen seconds to eliminate some of the waiting period while the drops formed. Superconductivity was demonstrated by " floating " a bar magnet over a cooled block of lead. The lead was allowed to heat above 7°K when, of course, the magnet gradually settled down on to the lead.

A television program has much more flexibility than a lecture. For example, it is often possible to present half a dozen leading experts each discussing his own work and demonstrating his own material, all inside half an hour, without undue compression. The B.B.C.

*Based on a lecture to the Education Group given at the Institute's House on October 8, 1958.

series " Eye on Research " has demonstrated how well this technique can succeed. The use of close-ups enables the audience to concentrate on the relevant while the irrelevant is eliminated. Film can be cut in as desired. This can sometimes make possible an otherwise impractical sequence. For example, a program in the B.B.C. series "A Question of Science" demonstrated the use of image intensification of X-rays. A " patient " was introduced into the machine in the studio and drank what purported to be a barium solution. The program then cut to a previously shot film showing the digestive processes by X-ray. At the end of the film insert the program went back to the studio. Such exploitation of the flexibility of the medium saves a great deal of time and maintains a continuity of action impossible without such justified " cheating." Television is able, by methods of this kind, to eliminate a great deal of " dead time " and so cover at least an hour's lecture material in thirty minutes. The use of Outside Broadcasts, or Remotes as they are sometimes called, opens up great possibilities for the coverage of science on a national or world scale as was shown to some extent in the B.B.C. program " The Restless Sphere " which was introduced by the Duke of Edinburgh.

SCIENTIFIC ACHIEVEMENTS OF TELEVISION

British television, both B.B.C. and I.T.V., has presented science in a serious and dignified manner. It has done a considerable service to science by presenting to the public many of the leading scientists. This has undoubtedly removed many misconceptions about the fraternity to which we belong. The public have had an opportunity to realize that scientists are not a race apart but rather specially trained men of high intelligence determined to satisfy their curiosity about the world around them.

Many hitherto unknown branches of science have aroused interest in the public mind through television. For example, the B.B.C. programs " Animal, Vegetable and Mineral " and " Buried Treasure " have been of service to archaeology as the public appreciation of the significance of the Roman treasures recently unearthed in London shows. Without the influence of television and the appreciation of archaeology engendered by it, it is likely that no steps would have been taken to call in professional archaeologists before irretrievable damage had been done.

One completely new technique introduced by television is the animated diagram (Fig. 1). Pioneered by Alfred Wurmser, such diagrams have reached an astonishing stage of perfection. In many cases they convey a principle much better than the real thing and they always provide much more information than a drawing or photograph.

Television has made a serious attempt in the last two years to present to the public a factual account of the contemporary work on the exploration of space. Several authoritative programs have been mounted among which may be mentioned two B.B.C. programs, " Space Travel " and " New Moons " and a series of four on Associated-Rediffusion under the general title of " Conquest of Space." Among the contributors to these programs were Sir Harold Spencer Jones, Sir

Fig. 1. *Animated diagram showing the action of the human heart. The animation is being operated by Alfred Wurmser who is also pointing to salient features. He receives his cues from the producer through headphones.*

Edward Bullard, Professor Bondi and many of the medical staff of the Institute of Aviation Medicine. One of the programs included a Eurovision link to the Soviet Pavilion at the Brussels World's Fair which brought the British public their first direct look at a full sized model of Sputnik II.

Science on television has provided the excuse, and the funds, to look closer at some odd facts and to investigate some unusual phenomena. An example of this was a series of experiments conducted on the acoustic shattering of wineglasses for the B.B.C. program " A Question of Science." There has been a well-known story in circulation for many years that the Italian tenor, Enrico Caruso, could flick a wineglass to establish its resonant frequency and then sing at this frequency until the glass shattered. Rather as an amusing scientific trick, it was decided to try this experiment using a loudspeaker fed from an audio frequency oscillator as a source of sound. Although a 100 watt amplifier was used, we had no success. A short while afterwards it was widely reported that Victoria Elliott had shattered three wineglasses while singing at the Dorchester Hotel, London. We immediately re-commenced experiments both with Miss Elliott and electronic sources. But, whatever we did, we could not crack a glass. Miss Elliott's incredibly powerful and flexible voice enabled her to set up oscillations of visible amplitude in a glass and the same effect could, of course, be produced electronically. Some hundred different glasses were

Fig. 2. *Samples sent in by viewers following an attempt in " A Question of Science " to break glasses acoustically. One of those being demonstrated shows the characteristic fracture 1 cm below the rim.* (B.B.C. photograph.)

tried including a dozen from the Dorchester. Various quantities of liquid were placed in them—including brandy ! Some were scratched to produce notch stress conditions and others had thermal stresses induced by heating and cooling in a blast of cold air. Thermal expansion gradients were produced by filling glasses with liquid air. Various audio signals were produced, pure tones at the fundamental frequency and multiples and sub-multiples of it, frequency modulated tones and signals with " white noise " superimposed. But whatever we tried we could not shatter a glass and, by the time we mounted the program we were convinced that glasses could not be broken. We repeated a number of experiments on the air and had Miss Elliott to delight us with her magnificent voice, but as anticipated all our glasses in the studio remained intact. Apart from a resourceful gentleman who rang up the B.B.C. as soon as the program was over to say that we had broken his cathode ray tube, what were we going to do about it, we felt that the matter was now closed. However, we soon began to receive some most interesting letters. Despite considerable literary research we had unearthed no details of Caruso's feat. Several viewers pointed out to us that Caruso's biography by his widow stated unequivocably that he had *never* bróken a glass or mirror in his life.[4] We also received twenty glasses that viewers claimed had been broken on the program, ten by Miss Elliott and ten by the oscillator. About twelve of these had broken cleanly about 1 cm below the rim (Fig. 2). Although we had not mentioned it on the program, we had found that all the glasses that we had examined under a pola-viewer had a characteristic strain line below the rim, probably produced during manufacture when the rim is flame treated to remove roughness. It seems highly probable that these glasses had broken during the program as claimed. If so there is obviously a statistical chance that a glass can be shattered acoustically but this chance is so small that it needs a 7 million audience to break 14 glasses !

I recently asked Dr. J. Bronowski what he thought were the most significant accomplishments of television science programs. He felt that television had been successful in making the public appreciate the significance of statistics and pointed out that after " New Horizon " had examined the 11 + examination letters in the press criticizing the 11 + no longer quoted difficult questions as an argument against using the examination for grammar school selection but rather criticized the validity of using such a test for selection purposes.

SOME LIMITATIONS OF TELEVISION

The immediately obvious deficiency of television compared with a lecture is the absence of direct feedback from viewers, in other words there is no immediate audience reaction. Every lecturer knows the satisfying atmosphere when he is " carrying his audience " and, with experience, he can adjust his pace to suit his listeners. On television this is completely lacking.

Although there are a number of studio staff visible, these are trained not to react—a somewhat disconcerting characteristic for the newcomer to television ! However, the performer has a highly trained producer who is capable of analysing the material during rehearsals and discussing its presentation with the performer. This performer/producer relationship is of crucial importance and an intelligent performer will take the producer's advice almost without question. Television has also organized its own delayed feedback from viewers by means of polls and listeners' panels. These give very accurate statistical information about the size of viewing audience and general reactions.

The lack of colour and, to a lesser extent, stereoscopy is a serious limitation of television. Subjects like dyestuffs and many branches of optics just cannot be presented monochromatically. There is nothing quite as dull as a spectrum as seen on television ! The limitations of definition, due both to the raster and finite bandwidth, and the various geometrical distortions caused by non-linear time bases eliminate many items, for example some of the more attractive optical illusions.

In general, an audience is a cross-section of the population—a heterogeneous mass whose IQ is 100 by definition. The spread is from the near idiot to the highly intelligent, from the unskilled labourer to the Fellow of the Royal Society. This makes the planning of any serious program extraordinarily difficult as the complex to the uneducated is trivial to the initiated. Television has one important characteristic possessed by almost no other medium. This is its ability to appeal simultaneously to more than one intellectual level. Experience has shown that visual interest can hold an audience while, for a limited time, advanced science can be presented aurally. During a B.B.C. program " A Question of Science " and an Associated-Rediffusion program in the " New Horizon " series advanced physics was discussed while beautiful pictures of low temperature phenomena were being shown. Both programs received higher viewer ratings. Undoubtedly there is still much to learn about this technique which is regularly exploited, not only in science programs.

There are certain technical limitations which are not understood by everyone which prevent many effects from being shown on live television. Television cameras are incapable of accepting subjects with large variations of illumination. This eliminates at one stroke the presentation of many self-luminous objects such as flames. In extreme cases such objects appear black (solarization) or " peel out," an effect similar to a poster being peeled off a hoarding. The existence of a raster causes moving objects to " strobe " and horizontal lines on an object to flutter due to the moiré fringe effect. The a.c. flicker on lamps can produce " hum bars " and discharge tubes run from the a.c. mains cannot be used for illumination. Very short-lived phenomena such as electric sparks cannot be shown as an event must last at least 10 milliseconds to be certain of one raster scan.

The conditions inside a television studio are not necessarily conducive to the success of scientific experiments. The bright lights prevent the application of the photoelectric effect in many instances while the heat of the lights and the thermal gradients set up can be disastrous as we found to our cost when trying to repeat the Herschel experiment on the air ! Such difficulties are not confined to physics. We once tried to demonstrate the characteristic wheeze of an asthmatic. With some special microphone arrangements this worked admirably on rehearsal but on transmission our asthmatic breathed perfectly. Alas, she had released so much adrenalin due to emotional stress that the wheeze temporarily vanished !

The apparatus used on British television for the projection of films can only operate at 25 frames a second—a sub-multiple of the mains frequency. This eliminates a great deal of otherwise magnificent film shot at silent speed, 16 frames a second. I would like research workers to realize that if they are making film of a unique nature they should always shoot it at such a speed that it can be projected at 25 frames per second not only for television but also so that it can have a commentary dubbed on it for ordinary theatre projection.

COLLECTING SCIENTIFIC DATA BY TELEVISION

The giant audience that television can command tempts one to use it to collect statistical data from mass experiments. Unfortunately there are good reasons why this is usually unsatisfactory. If one uses a questionnaire to be filled up by viewers, the sample who return answers is unrepresentative. It is almost impossible to arrange controls and " cheating " cannot be eliminated. Families will almost certainly collaborate to try and get a good score while people who cannot answer some of the questions will usually refuse to submit their questionnaires.

There is, however, one application of the medium for collecting data that can be phenomenally successful. This is the finding of the unusual such as the broken wineglasses previously mentioned. There have been a number of examples where scientific programs have enabled most useful data to be accumulated. A B.B.C. program " Twin Brother, Twin Sister " in the series " Science in the Making " transmitted in 1953 resulted in finding 38 pairs of uniovular twins separated at birth and reared in different environments. Before the program only twenty sets had been studied in the whole history of genetics ! Such separated twins who have identical genetic traits are invaluable as a means of separating hereditary and acquired characteristics. One of the psychiatrists who assisted in the presentation of the program has subsequently written a paper on the examination of the separated twins that were found.[5]

Another program in the same series (" The Sense of Sight," February, 1954) enabled us to find a youth who could see the moons of Jupiter with the naked eye. Such people had been mentioned in the literature but none had previously been examined under laboratory conditions. A scale model, correct in terms of relative brightness, was constructed to test viewers claiming they could see the moons. Only one viewer succeeded and so critical was his success that he failed when hungry until several cups of sweet tea raised the sugar content of his blood to the necessary level.

In the B.B.C. program " A Question of Science " transmitted on June 22, 1956, an interesting experiment

on subliminal perception was carried out. During a film sequence one frame was inserted containing a four word news item. This appeared on the screen for 1/25 second and was put up without warning. At the end of the program I told viewers that the experiment had been conducted and asked them to let us know their responses. We received 430 postcards, 20 viewers got the message correct and 134 got three words out of the four. There were a number of rather odd results including one woman—a psychologist—who reported that she had not seen the message consciously but woke several times during the night with the word " breaks " in her mind. Another woman reported that she was only conscious of the words when she was washing up after the program—she reported them correctly. The actual message was a topical news item, viz. " Pirie breaks world record." Although this mass experiment would not satisfy a psychologist because of the absence of controls it was, nevertheless, of considerable interest qualitatively. In the following "A Question of Science," the producer, James McCloy, put up another subliminal message asking viewers to write in and say which of the several scientific questions answered on the program interested them most. The response was precisely nil ! This rather disposed of the theory that people could be seriously influenced by subliminal television messages![6,7]

TECHNICAL TRICKS

Television has developed a number of special technical tricks. Some of these have been borrowed from the cinema, óthers are unique to television. A few of these, with some applications, follow :

Inlay—an electronic system whereby a picture from one camera can be inlaid into a picture from another. Special applications are split-screen and wipes. Inlay is useful when two different scenes need to be viewed simultaneously, e.g. watching the recordings from an encephalograph at the same time as the subject's face.

Overlay—an electronic system which enables pictures from one camera to be overlaid on pictures from another so that moving backgrounds can be inserted without superimposition.

Zoom lenses—lenses of variable focal length enabling change of picture size to be effected without changing the distance between camera and object. Due to the fact that there is no change of perspective this is not a substitute for a track shot. It is of particular value in Outside Broadcasts where camera positions are fixed.

Back projection—optical method of inserting still or moving backgrounds. Has been used in scientific programs to insert large stills such as meteors and dinosaurs behind the speaker.

Autocue and Teleprompt—apparatus which enables speakers' script material, either verbatim or as " lecture notes " to be presented on a moving roll of paper on one or more cameras. "Autocue" (Fig. 3) is fitted just above the camera lens, " Teleprompt " projects it by a Pepper's Ghost optical system in front of the lens.

Phase reversal—electronic method of producing a negative picture. Useful to improve legibility of diagrams and much used for newsreels which are projected as negatives to save time in making a positive print.

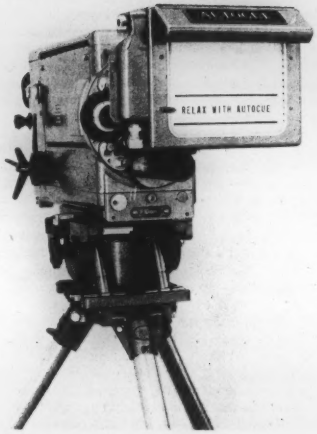

Fig. 3. *AUTOCUE apparatus fitted to a television camera. The material presented is printed in large type on a roll of perforated paper. The paper is run electrically from a master control. A lamp above the paper makes it readily visible to the performer.* (Photograph by courtesy of Autocue Ltd.)

SPECIAL PROBLEMS OF SCIENCE ON TELEVISION

Performing on television is not particularly easy. Many scientists are extremely experienced at lecturing but, unfortunately, the technique cannot be carried directly into the new medium. Television is intimacy on a grand scale. A performer's audience is one person, not millions, and the presentation must take account of this. Every scientist knows the force of understatement in a scientific lecture—but understatement on a medium that has the odd quality of cutting everything down is quite ineffective. Physicists, with one or two brilliant exceptions, have proved disappointing on television. A major problem is the specialist jargon which we all use and which has become so complex that a physicist in one field often has difficulty in fully understanding a colleague in another field. Although no-one is likely to use a sentence like, " Most flip-flops have the characteristic that they will not flip satisfactorily immediately after they have flopped," nevertheless specialized terms prove a real barrier. Medical men have the great advantage that they are used to talking to patients and can unconsciously choose their language to suit their audience much better than physical scientists. Another barrier between the scientist and the public is caused by a scientist's demand for absolute accuracy. This demand must, of course, be met in all circumstances—it is

absolutely essential that inaccuracies and ambiguities should be rigorously excluded from television material. But, on the other hand, the public cannot be expected to extract from a scientist's characteristically guarded statements the implications of his work. The solution is the most careful choice both of subject matter and wording so that integrity is maintained without sacrifice of intelligibility. This problem is by no means insuperable but it needs special knowledge and requires an interpreter. Like all interpreters, this person must be familiar with the languages of both sides. In other words, he must be a professional scientist who has made a study of presentation to the public. Unfortunately such persons are rare. If scientific television is to be the force that it should be, more professional scientists will have to study the techniques of presentation of material. This study includes the psychology of mass reception and is significantly different from conventional educational methods.

An example of the planning of material to avoid some of the pitfalls of ambiguity was in a recent Associated-Rediffusion program in the series " New Horizon." This program, entitled " Smaller than Atoms " dealt with quantum physics. The first decision was that it was impossible to deal with wave mechanics. Hence the script was so worded that we said, " One way of looking at the atom is . . . " and we then described the Bohr model. We then ruthlessly eliminated elliptical orbits and the complications of azimuthal quantum numbers by considering only the unexcited hydrogen atom in detail with passing reference to more complicated atoms. We were then able to plan a program which was intelligible to the non-physicist but completely accurate in the limited field that it explored.

Present day television suffers from the undeclared war between the two networks, B.B.C. and I.T.V. Under the terms of the Television Act, the commercial operating companies are forced to plan programs during peak viewing hours 7.30-10 p.m.[2] for maximum audience. This is because advertising time must be sold on numbers and not on prestige as the advertiser can have no influence on the program during which he has his " spot." As the public tends to stay on the channel to which it is tuned, the B.B.C. has to fight I.T.V. during peak hours in order to get an audience at all. Hence, there is little likelihood of presenting material with minority appeal during these hours until there is a third channel. The B.B.C. are currently transmitting a fortnightly science series, " Science is News " at 8.15 p.m., but this program aims at a large audience.

There are certain necessary taboos in scientific programs. Medical subjects must be treated with circumspection to ensure that there is no danger of self-diagnosis or either the raising of false hopes or despondency. So powerful is television that an unguarded word about a cure for a disease will fill every doctor's surgery the next day !

The present shortage of studio space and studio staff limits the opportunities of arranging closed circuit experimental sessions when experiments can be tried before cameras. This tends to make producers " play safe " and there is a great need for a television research group such as exists in France under Radiodiffusion-Télévision Française.

There is also the special problem of the man who refuses to have a set in his house and then proceeds to criticize material he has never seen ! Time will, of course, eliminate this man as he was eliminated from sound radio which is now respectable in his eyes ! Television thrives on intelligent criticism and we all encourage it as much as possible. But no advantage is gained by the " blanket critic " who only demonstrates his own stupidity.

TELEVISION FOR CHILDREN

A recent report has[8] confirmed that television has a large influence on children. Both channels reserve about an hour a day, between 5 p.m. and 6 p.m., to programs for children's entertainment. Both B.B.C. and I.T.V. have regular science programs appearing in this hour. Science for children's entertainment must be carefully planned if the difficult course between amusement and education is to be satisfactorily negotiated. It is quite useless to mount a serious educational program on the lines of a school lesson if Popeye is on the other channel. On the other hand there is a real thirst for knowledge to be satisfied among children starved of any science in school.

If we consider such programs from the point of view of the scientific future of the country I feel that we must endeavour to interest children in science, demonstrate that it is an exciting subject totally divorced from the Victorian textbook and show something of the part it plays in our modern living. This entails the selection of stimulating subjects and their presentation in a visually exciting manner. An experiment whose elegance delights a professional scientist may mean nothing to a schoolgirl of ten, but a rubber ball smashed with a hammer after being immersed in liquid air will leave the impression that there is a new world outside our own experience which it is exciting to explore. Such a philosophy is one of the foundations of science and well worth imprinting in our younger generation.

It has been argued that one of the disadvantages of television is that it is a passive experience. It is therefore of particular importance to encourage children to try and do things for themselves and a number of programs such as one in the B.B.C. series " Experiment," which dealt with radio controlled models, invite children to build their own equipment.

It is only relatively recently that British television has presented programs for schools. The first schools' series was transmitted by Associated-Rediffusion in the summer term of 1957. In September the B.B.C. began its two years schools' experiment with five programs weekly, approximately the same output as Associated-Rediffusion. Both channels have presented at least one science program a week. Examples are " A Year of Observation " and " More Power " (A.-R.) and " Living in Water " and " Stress and Strain " (B.B.C.).

Schools' television has a completely different approach from any other television programs. The audience is defined and " captive " and there is a qualified teacher both to prepare the class for what is coming and to follow up what has been done. Teachers receive special

notes about programs in advance which detail the material to be dealt with and offer suggestions for follow up lessons. Both B.B.C. and I.T.V. have taken the attitude that television can never *teach* as well as a teacher. But it can supplement the teacher's work and bring to the classroom material that is beyond the scope of the teacher. The present target is the Secondary Modern School. There are two good reasons for this choice. One is that there are more Secondary Moderns than any other type of school for older children, the other that the less bright children can probably extract more benefit from a visual aid such as television than grammar school children can.

A feature of schools' television perhaps not generally appreciated is that mothers can watch the same programs as their children and so enter more fully into their scholastic experience. It is known that there is a very large adult audience to schools' programs, many of them presumably parents.

THE FUTURE OF SCIENCE ON TELEVISION

Many of the restrictions on serious programs will be removed with the availability of more channels. It may be presumed that the time is not too far distant when television will have its "Third Program" when minority audiences can be fully catered for and when there will be the opportunity of exploiting the medium for adult education. Colour television is already a practical possibility. Some further research and development may be necessary to improve the long term stability of colour receivers, otherwise colour becomes merely a question of economics. The recent development of methods of recording television programs on tape with almost no loss of quality will undoubtedly have as great an effect on the general mechanism of television production as sound recording has had on ordinary radio. In addition to making repeat programs highly economic, recording will enable television to cover events occurring at inconvenient times for direct transmission as is the case for many historic scientific experiments.

Television has the opportunity of making science as much a part of man's culture as the arts are. It could follow the lead that sound radio has given in the raising of the cultural level of the country in music, by giving every man an appreciation of the significance of science. And it only needs to encourage one budding Newton to read science to have made all the effort worthwhile.

REFERENCES

1. *G.P.O. Press Release*, 16 P.O.N.B., November 28, 1958.
2. Television in Britain, *Planning*, **24**, 420, March 24, 1958, P.E.P.
3. Johnson, M. L., Seeing's Believing, *New Biology*, **15**, 62, Penguin Books, London.
4. Caruso, D., *Enrico Caruso, his Life and Death*, 157, T. Werner Laurie, London.
5. Shields, J., Twins Brought up Apart, *The Eugenics Review*, **50**, 2, July, 1958.
6. Garratt, A. J., L'Excitation Subliminale, *Cahiers d'Etudes de Radio-Télévision*, **13**, Radiodiffusion-Télévision Française, Paris.
7. *Subliminal Communication*, Institute of Practitioners in Advertising, London, 1958.
8. Himmelweit, H. T., *et al.*, *Television and the Child. An Empirical Study of the Effect of T.V. on the Young*. Oxford University Press, 1958.

From Industry to Technical Education

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"We are living in an age of transition." So Adam is reported to have said to Eve when they were thrown out of the Garden of Eden and so it is in technical education to-day. In writing about education when it is only just over twelve months since I arrived here from industry, I feel like the man who writes a book *Russia To-day* after having spent only a few days there on a business trip. However, perhaps there is virtue in recording first impressions before one becomes so steeped in the new way of life that it ceases to shock.

The rapid expansion in technological education taking place at the present time, is part of the Government's policy to increase the annual output of technologists in order to meet the increasing needs of industry. In addition to a considerable program of university development, a sum of £70 million is being devoted to technical college building over the period 1956-61. The intention is to secure a 50 per cent increase in the output of students from advanced courses in technical colleges.

Right at the heart of this surge in technical education lie the sandwich courses leading to the Diploma in Technology. At the highest level, sandwich courses usually extend over four or five years. Entrance requirements are roughly equivalent to those for admission to a university. In each year, the students spend six months in the college followed by six months in industry. As the Minister of Education said recently of the sandwich system : " In a sense, it is the application to industry of the educational system long used in medicine where the medical student has a prolonged period of study during which he is also walking the wards in the hospital."

Students who have successfully completed recognized courses of this kind will be awarded the Diploma in Technology by the National Council for Technological Awards. In their first report, the National Council announced that it had approved 50 out of 104 courses submitted by various colleges for recognition. From these courses, and the many others which will doubtless be recognized in the next few years, many of the technologists of the future will come. Clearly the pattern of technical education will be essentially that of the sandwich courses. It should be noted in passing that there are sandwich courses leading not only to the Diploma in Technology, but to university degrees, to Ordinary and Higher National Diplomas, as well as certain college diplomas. Nor is it right to convey the impression that sandwich courses are a new thing. They have existed in the Royal Technical College, Glasgow, for example, since 1888, though the industrial and college periods were not so closely linked as it is hoped to make them nowadays. Clearly, the success of the sandwich system depends on close co-operation between colleges and industry, so that the industrial period can, in a real sense, be as much of a training period as the college period is. College staff and industrial personnel need to understand each other as never before. The Government has recognized this by announcing its intention of recruiting teaching staff from industry as much as possible.

To the man outside education, particularly the research man in industry, this picture presents an attractive possibility of combining academic work with industrial application in a situation where his industrial contacts seem likely to prove more valuable than they would in many university departments. Also, he gets the impression from advertisements for teaching staff, which so often contain the phrases " Research encouraged " or " Facilities for research are available," that he is about to enter an institution in which everyone is madly keen on research work but that a certain amount of incidental teaching has to be done. What are conditions really like in technical education at the moment ? First, it must be said that there are considerable differences between one college and another. Conditions depend on a number of factors, amongst which the most important are probably the attitudes of the Governing Body, the Principal and staff, and of local industries. Some colleges place teaching first and foremost. They claim that their main aim is to produce technologists and the staff are there to do just this. Others believe that industrial co-operation is best won through research. Indeed, it is sometimes a condition of employment that research work should be undertaken. To a large extent, details of college policy must be formulated according to the availability of local industries and the relationships with them. Let us briefly examine the general conditions which are likely to hold in a college which claims to encourage research work.

The different teaching grades existing in a College of Advanced Technology range from Assistant Grade B through Lecturer and Senior Lecturer to Reader. Broadly speaking, the more senior the grade the shorter the teaching hours expected, and the greater the salary and allowance of time for research work. The Head of a Department, however, is likely to find his time fairly fully occupied with administrative and other general duties so that, whilst he may be paid more than a Reader, though this is not always so, his opportunities for research are likely to be less. In an enlightened college, an Assistant Grade B may have some 16 hours teaching to do each week for a salary in the range of £650 rising by annual increments of £25 to £1,025. Near the other end of the scale we have a Reader, teaching perhaps 10 to 12 hours a week with a salary rising from £1,550 to £1,800 by annual increments of £50. These scales refer to men, and in all cases there are London allowances, and possibly increments for industrial experience to be added within the scale. A Readership is rightly regarded as one of the plums of the profession. It is fair to say that these conditions

compare not too unfavourably with those in universities, especially when it is realized that of the so-called " teaching hours " often only one half to two thirds are devoted to lecturing. The rest are occupied with tutorial work and laboratory demonstration. Nevertheless, salaries are still appreciably less than those in corresponding university grades. There is in fact some evidence which suggests that lecturers' conditions are not yet sufficiently attractive to the right men either from the universities or from industry but that senior lectureships offer some attraction. It is, however, difficult to generalize in view of great differences between one subject and another. Thus engineers, being in great demand in industry, are particularly difficult to entice into education.

To digress for a moment, it must be borne in mind, when comparing these salary scales with industrial ones, that by and large the staff are in the college for only three-quarters of the year. How long this state of affairs will survive, as contacts with industry, where a three-weeks summer holiday is a long break, become closer and closer, remains to be seen. It is likely to emerge as a national problem, too thorny to be more than hinted at here. One aspect of the problem, which may well force the issue, is that some industrial firms are calling for end-on sandwich courses leading to the Diploma in Technology. They are willing to double the number of their trainees so that, at any time of year, one set can be in the college and one in the firm, the two sets changing round every six months. In this way, the firm has the same number of employees at work throughout the year. Clearly, this is good for the firm but constitutes a severe headache to Directors of Education and Principals of colleges since it will involve some staff being available throughout the year. It may be that an industrial man at any rate would be more strongly attracted to technical education if the holidays were less and the pay correspondingly more. At least, I am sure this would meet with the approval of most wives.

So much for the time available for research : what of the facilities ? Most research work nowadays, even in mathematics, needs equipment which is often expensive. Some colleges are fortunate in having industrial backing for some research projects which removes financial worries at least, and enables up-to-date equipment to be obtained quickly. Otherwise, probably the first major obstacle which an industrial man will meet in a college is that of getting approval to spend money on apparatus and machines. If an industrial Board of Directors appoint a research man they expect to finance him immediately and provide enough apparatus to get him launched. In education, on the other hand, nothing it seems, can shortcut the long train of events, which in effect results in a delay of over 12 months, before final orders for equipment can be placed. First a list of estimates for capital expenditure is submitted to the Governors. From there it goes to the County Authorities who pass it to the Ministry of Education. After months of delay, one of Her Majesty's Inspectors will probably arrive to discuss how essential this equipment is and try to persuade the college to accept a slide rule, or, if he is feeling very generous, a planimeter instead of an analogue or digital computer. However, if by some strange mischance, he is convinced of the righteousness of the case, he will ask the Ministry's approval. So much for the first stage. The second stage comprises the same set of operations, through Governors, County, Ministry, though this time the working substance is a quotation from two firms for each item requested. I personally have not yet lived long enough in education to see the end of the chain of events but I am assured that, ultimately, definite orders can be placed. To a keen research worker straight from industry this can be a blunting process.

The excessive caution is doubtless because public money is being spent, but if education is to attract personnel from industry it must try to provide conditions more closely resembling industrial ones. This applies not only to facilities for research but in regard to general conditions of service. In industry I had only to pick up a telephone to get a car and a driver ; now, in a job carrying more responsibility, I take a trolley bus and waste hours. If satisfactory industrial contacts are to be maintained, the whole college staff need to be mobile and everything possible should be done to facilitate travel. Is a car allowance too much to ask and how long will it be before education accepts the aeroplane as a legitimate means of travel ? The college lecturer is very much the poor relation when he attends a conference alongside industrialists. It is whispered that even a Director of Education has to " cook " his petty cash account in order to entertain a business acquaintance to lunch. There seems no reason why Local or County Authorities cannot delegate to Principals the power to spend money within prescribed amounts agreed by them and the Governing Body, say once a year. Otherwise, frequent application to spend trivial sums soon becomes irksome, even though permission is readily granted. It is surely unnecessary, for example, for a Head of Department in a London college to have to make separate application in writing to County each time he wishes to attend an afternoon meeting in Cambridge, so that his expenses may be reimbursed.

Meanwhile, what is the attitude of established teachers to this expansion and influx of strange beings from the industrial world ? It is to be expected that the man who has been teaching, maybe for twenty years or more, should have a different outlook from one who has spent his formative years in industry. It is for the Head of the Department to try to ensure that these different experiences are blended and made complementary, otherwise there will almost certainly be cleavage between the two groups of staff. The teacher should realize that, though he knows all there is to know about the art of teaching, he may have been out of touch with the industrial world for so long that he has little to offer to advanced students particularly in sandwich courses leading to the Diploma in Technology, where students are themselves in industry for six months in each year. Equally so, the industrial man will be much more at home and successful with advanced and postgraduate classes, but find that he has long since forgotten what a student straight from school can be expected to know. Unless he takes pains to adjust the content and speed of his lectures to junior

classes, he will receive and rightly so, the scorn of his teacher colleagues, some of whom will tend to look upon him as an interloper to their teachers' world.

When we come to industrial contacts, however, the boot is on the other foot. It is a vital part of the Diploma in Technology courses that intermixing should take place between the college staff and personnel from local firms. Some colleges have introduced a system of industrial tutoring whereby each member of the staff is tutor to a small group of sandwich course students. The tutor visits his student perhaps once a month during the time he is in industry, sees him at his job, discusses it with him and with his superior in the firm who is directing him. Here are excellent opportunities for teachers and lecturers to spring clean their knowledge of industry and for industry to learn of educational problems. The established teacher, however, is often either unwilling to do this visiting, which he may even consider to be beneath the dignity of his profession, or if he tries, finds some indefinable but very real barrier. It is almost as if they were talking a different language. He tends to adopt the attitude that industry should accept what education offers and be thankful. This is an outmoded approach. Education must do its utmost to provide what industry demands which usually is something very sensible—a man with some personality (a potential leader as he is often described) a man who can think for himself and has some specialist knowledge thrown in.

The lecturer who has but recently left industry is only too ready to keep in touch with technical development. Clearly, nothing but good can come from the fusion of trained teachers and industrial recruits on the lecturing staff if they are willing to be tolerant and to learn from each other. Indeed, it is probably true that this successful merger is one of the most important single factors on which the success of technical education is going to depend.

I have long held the conviction, and even my relatively short sojourn in education has strengthened this, that to combine research with some teaching is to have the best of both worlds. The full-time research worker finds it very hard indeed not to get into a narrow rut of specialization. A full-time teacher, on the other hand, easily becomes jaded and his critical faculties blunted by teaching the same material to those who are usually his intellectual inferiors. To combine research with teaching, however, is to keep in touch with the broad foundations of the subject and at the same time to preserve a humble, enquiring spirit in the face of unsolved problems.

Gone are the days when it can be said that education is the colleges' business and they should be left to get on with it as best they can. The present, rapid expansion is being stimulated by industry's need for more technologists and it is therefore only fair to ask that industrial firms should help the colleges with their task. The cost of much of the equipment needed is too great for the Treasury and local authorities to bear. Much help has already been given and many colleges can quote examples of equipment received from industry or other outside sources. No doubt we shall in time see colleges containing modern machinery given and maintained by private enterprise or nationalized industries. The universities have come to depend more and more on outside help in this way without losing their independence and there seems no reason why the same should not happen in colleges of technology. At the same time, there is a factor to be borne in mind which operates the other way, namely that sandwich-course students spend six months of each year in industry. There they are very likely to use large and expensive equipment and this, to some extent, mitigates the need for such machinery in the colleges. On the other hand, not only the students in a college but also the staff may make use of large-scale equipment for research and other purposes. A college which is well equipped is likely to find it easier to attract the right sort of staff. For example, a sizeable electronic computer may draw staff not only to the mathematics department but to other departments as well.

A less tangible but equally valuable form of help which industrial firms can give is to allow their staff to sit on advisory panels. Such panels, meeting perhaps once a term, with the Principal, Heads of Departments, and probably one or two members of college staff, can give advice on several matters. Included in these could be : (1) the type and content of courses industry needs, (2) the supplying of students for such courses, (3) the arrangement of students' six-monthly training periods in industry, (4) the development of research and project work, (5) recruitment of both full-time and part-time teaching staff.

One further thing required of industrial firms is that they should be willing to take teaching staff for refresher courses as often as the colleges can spare them. This I know is more difficult than it sounds especially in the case of the established teacher when it is not a " refresher" course but an " initiation " course which is needed. It is a vital requisite, however, that, somehow or other some college staff should keep an " inside view " of certain industries. This is another of the problems which educational authorities and industry must tackle together if teaching, project and research work in the colleges are to be lively and up-to-date.

In spite of what has been written here, there are encouraging signs that education authorities on the one hand and industry on the other are trying to make conditions in technical education as attractive as possible to the research-minded or industrially-minded man. Naturally, there are many matters to be put right. Accommodation cannot be doubled overnight and so there must inevitably be a trying period of overcrowding. Also, the development of new courses puts a considerable strain on all concerned, including students, who must, to some extent at least be educational guinea pigs. But there is no shortage of exciting and stimulating problems to satisfy new recruits to the staff who are robust enough to withstand the petty frustrations and setbacks which must inevitably be experienced in this initial teething period.

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Writing about Science*

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FIFTY years ago it would not have been considered necessary to write about writing about science. Even before the war, when there were many distinguished publicists of scientific things and when public interest in these had begun to grow quickly, it was still not necessary to be introspective about the subject. Writing about science was not necessarily different from writing about archæology, or golf or diplomacy.

In a sense this view is still correct. To the extent that writing is the craft of stringing words together and that the practice of this craft demands skills of one kind or another, it does not matter whether the subject is the negotiation of a treaty or the design of a new atomic reactor. It is on this basis that so many newspaper editors argue—with help from the doctrine that expertness is usually dull and often actively bad—that a fresh mind, however untutored, can usefully add to public understanding of what science is about.

I do not wish to suggest that the results of this practice are always unfortunate, or to argue that only scientists should be allowed to write about science. How, in any case, could such a doctrine be imposed? What I do want to argue is that the whole field of science presents writers with difficulties which are both novel and, quantitatively, considerable; that nevertheless it is important that these difficulties should be overcome in a way that will bring a clear understanding of the motives and methods of scientists to a growing audience; and that, in this way, both the public and the scientific community will profit enormously.

My own experience is with a daily newspaper, and what I can contribute to this discussion is coloured by what I have learnt in this narrow field. Even so, the difficulties with which I have to contend may not be so very different from those which beset all science writers. I should enumerate some of them so that it will be plain that the difficulties are real—not imaginary ones dragged in to make science writing sound like a high priesthood.

The most obvious difficulty is that one is almost certain to be preyed on from time to time by the belief that one knows more than one does. This is a terrible trap. Trained scientists who have turned writers fall into it just as often as their colleagues who may have begun as crime reporters or novelists of character. I have found myself making assumptions about things like the age of Triassic strata or the kind of fuel to be put into a nuclear reactor which, in the end, turned out to be incorrect. Yet these are questions of fact, and can easily be decided by reference to the appropriate sources of correct information. It is much easier to think that one knows what motive has inspired some experiment or another—and to be entirely wrong.

The only remedy for this is that those who write about science should somehow be persuaded that humility is the most useful virtue which they can possess. In science things are changing so quickly, and so many old notions are being qualified as new work catches up with the classical, that without constant checking of detail and interpretation nobody can expect to present the balanced perspective of science which ought to be the product of science writing. By keeping enough statistics you can always be sure of a balanced view of what is happening to an institution like the National Coal Board, for instance; on the other hand no card index will help you to know what is really happening at the growing points of nuclear physics or biochemistry.

Some personal matters may be worth recording here. Thus I have found that it is usually better to check the accuracy of facts and interpretations with young people. On the whole—and there are valued exceptions to this statement—distinguished Fellows of the Royal Society are not very helpful, either because they have not troubled to remember the facts or because they will not commit themselves to any clear interpretation for fear of being wrong. Younger people, on the other hand, I have found to be usually expert and sufficiently in touch with uninhibited enthusiasm for them to be able to say what the inspiration of a particular experiment may be.

The unfortunate thing is that so few of the younger research workers appear to have graduated to the use of a telephone at home.

So much for the science writer. Given some skill with words and humility of the kind I have described, he will be able to turn out something which is readable, accurate, fair and illuminating. The intellectual level at which he can do this—whether he can satisfy the curiosity of professional scientists or only of children—will depend of course, on his other peculiar skills. But what of the material which he has to work with. The science—and the scientists.

Here one has to accept that a popular article about science cannot be as complete as, say, a paper in a scientific journal. Somewhere there must be selection. Facts which seem to be of great importance to the scientist whose work is being described must be left out because they do not add much to the main theme of the popular article, or because they would require too much appended explanation or perhaps simply because there is no space for them. It would be an excellent thing if practising scientists would forgive us these sins of omission if there is any reason to think that they are not just oversights.

One kind of omission does however seem to demand special justification. On the whole newspaper science in the last decade has been largely the preserve of the physicists and engineers. Atomic energy, aviation and space travel have made the headlines—and rightly—but recent developments in biochemistry which seem to me to be equally important have been largely ignored.

*Based on a lecture given to the Manchester and District Branch of the Institute on October 20, 1958

I do not think that this has arisen from malevolence or even short-sightedness. The real trouble is that biochemistry happens to be a subject about which it is extremely difficult to write intelligibly. It is for example almost impossible to explain in print and for a layman just what Sanger's structure of insulin looks like. Equally it was difficult to explain what non-conservation of parity meant when the news agencies sprang the news of Lee and Yang's experiments on astonished newspaper offices one night three years ago.

In my view one has to accept the selection which the need to be intelligible entails as gracefully as one can. Ordinary people have learnt the jargon of electrons and neutrons and protons in the last ten years. They have not yet acquired a feeling for amino-acids, and so a whole field of science is still closed to them. But science writers can, I think, do a great deal to help. Repeated explanations of why amino-acids are important in understanding protein structure will prepare the public for the day when headline writers are itching to write something like " British Scientists Make Life. Protein synthesis goes on in test-tube."

This reference to headlines raises another difficulty, at least as far as those who write for newspapers are concerned. In a sense newspapers are properly concerned with sensations, partly because people find it easier to read about sensations and partly because of a belief that sensational happenings are more important than those which are not sensational. For these reasons newspapers, however chaste their typography may be, are constructed so as to show off to the best advantage the material which appears to be dramatic or topical or sensational.

Unfortunately for us, most science is not news in this sense. Few events of real scientific importance can be said to have happened at such and such a time. You cannot write things like " Last night at 7 p.m. a heavy meson was discovered in a cloud chamber on the Pic du Midi " or " The decay of pi-mesons directly into electrons was demonstrated at Cern over the week-end." Science is not like that. That is, however, how newspapers would like it to be. This contradiction explains why some newspapers almost entirely ignore serious science (sputniks and the like apart), why others dress the subject up in wierd exaggeration which is offensive to professional scientists. Even for the serious papers, however, it is necessary to pay some heed to this convention and so it is that it is on many occasions difficult to write about the things which really seem to be important and, on other s, to make use of what may seem to be comparatively tri ial fact to introduce an explanation of something tha ought to have been dealt with months before.

This limitation on the use which can be made of newspapers explains why one should not expect too much of them. When the educational system has caught up with the times, and when an intelligent appreciation of what science is all about is no longer considered to be exceptional among ordinary people, newspapers will of course be able to do much more. That will be the hey day for the science writers. But in the meantime one should not expect that newspapers can do much to help the schools and the universities in the spreading of a scientific culture.

What then can they do ? In the first place they can usefully provide an information service for pofessional scientists. It is all too easy to underestimate the importance of this part of their task. I have been surprised to see how widely appreciated this kind of thing really is. An example which is obvious here is the way in which my newspaper printed daily the predictions about the position of the sputniks for several months after the launching of the first. Another facet of this service is the way in which several newspapers have for some years provided a continuing record of what is happening in the development of nuclear power.

Professional scientists appreciate this service not simply because it is not adequately provided elsewhere but also because the daily publication of newspapers can lend an air of topicality to the whole affair. But at this point I must enter an important qualification. If one hopes to do a useful job for professional scientists one must reckon to keep up a continuing interest—which entails that newspapers must be prepared to sacrifice some of their prejudices about what constitutes hot news —and, above all, one must be accurate. Nobody can blame if an obvious inacuracy in a newspaper report persuades him to take no notice of what the journal may say afterwards.

More important, however, is the way in which newspapers can add to a public appreciation of what science is about. I have already explained that I do not believe that newspapers can do an educative job. That is for the schoolmasters and their colleagues. But they can, I think, adequately explain what significance can be attached to particular scientific developments. It is possible, for example, to explain what significance should be attached to the design of a new kind of atomic power station or to an experiment in thermonuclear fusion. It is possible to explain what sputniks are for (and in particular to persuade people by rational process that the whole of science fiction has not become fact). In general it is possible to do this job in a way that will allow laymen to understand the reasons why some things are important and why some are not.

Wearing this hat, however, the science writer must guard against several dangers, two of which are worth recording. They must defend themselves against xenophobia—the kind of sentiment expressed in the headline " Britain does it again " or else they will merely add to the growing belief that science, like athletics, is really only a matter of national prestige. They must also guard against the beguilements of science as a source of amusing gimmicks. It is all too easy to win some fun from the notion that a university department may be milking radio-active milk from goats fed with radio-iodine without saying what the experiment is in aid of, for example. Both these pitfalls are hard to avoid because newspapers (and their readers) are the things they are, but none of what I have said should detract from the principle that good science writing should be amusing and not solemn because it is more easily read that way.

But to return to the main point. By informing the public about the importance of scientific developments

newspapers can help to form that climate of opinion in which sensible public decisions—many of them political—can be made. One only has to think of questions like "Should Britain launch earth satellites ?" to recognize how important it is that decisions on matters like these should not be left to Government departments simply because the public as a whole is not sufficiently informed about the issues involved to be able to exercise the kind of judgement expected of it when changes of income tax and the like are involved. At the same time it is not unimportant that the kind of job which newspapers do can do a great deal to remove the suspicion of science and scientists which appears to be more common than is usually realized.

From what I have said you will recognize that my view of the importance of writing about science is on the whole an empirical one. We are neither educators nor scientists, and much of what we do would not be necessary if the public was more adequately informed about the ways in which scientists work and the objects which they set out to achieve. The fact that science writing is considered to be a speciality at all is but a recognition that there is something worng with the society in which we live. The ideal state of affairs would be that in which science, like literature or diplomacy, was just a part of our everyday culture. But this having been said, you will of course not find it hard to agree that this ideal condition is a long way off—people like myself will be able to earn a living for many years to come.

Notes and News

New Year's Honours List

The names of the following Fellows of the Institute appear in the recently issued New Year's Honours List :

Professor Marcus Oliphant	- K.B.E.
W. A. S. Butement - -	- C.B.E.
Professor H. C. Webster -	- C.M.G.
P. W. Mummery - -	- O.B.E.
R. J. Bracey - - -	- M.B.E.

Payment of Subscriptions

Members are reminded that the form that should accompany remittances of annual subscriptions was included in the January *Bulletin*. Extra copies may be obtained from the Institute if required.

Peaceful Uses of Atomic Energy

The British Nuclear Energy Conference, of which the Institute is a constituent member, has arranged a Lecture Symposium reviewing the Second Geneva Conference on the Peaceful Uses of Atomic Energy. This is to be held at the Central Hall, Westminster, on Friday, March 13 next, at 9.30 a.m. – 5 p.m.

The speakers are Sir John Cockcroft, Dr. J. V. Dunworth, Professor J. Diamond, Dr. H. Kronberger, Dr. H. M. Finniston, Professor J. M. Kay and Mr. D. W. Fry.

Admission is free, and tickets are not required.

Non-Destructive Testing Group

The Non-Destructive Testing Group announces that the dates of two of the meetings published in the January *Bulletin* had been interchanged. The discussion on "What Industry requires from Non-Destructive Testing" will be held on March 13 at 2.30 p.m at The Institution of Electrical Engineers. The lecture by Professor Homès will be given in Sheffield on April 10.

A preliminary circular about the March meeting is available from the Institute.

Physical Society Conferences

The Physical Society has arranged the following conferences :

March 19 and 20 — Birkbeck College, London, on Fluctuation phenomena and stochastic processes.

April 8 to 10 — Clarendon Laboratory, Oxford, on Nuclear physics, to include high energy physics and electron collision processes.

July 6 and 7 — Durham University, on Co-operative phenomena and phase changes.

Members of the Institute who would like to attend any of these should write to the Secretary of The Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7, for details.

Conference on Refrigeration

Commission I of the International Institute of Refrigeration will be holding a conference in Copenhagen from August 19 to 26, 1959, as part of the tenth International Congress of Refrigeration. It is intended to discuss the following topics at the meeting : Applications of Low Temperature Techniques in Nuclear Physics ; Mechanical Properties of Metals at Low Temperatures ; Thermometry ; Industrial Problems in connection with the Liquefaction and Distillation of Gases ; Equation of State of Mixtures ; Fluids under High Pressure ; Transport Phenomena in Gases, Liquids and Solids ; other problems of the application of Very Low Temperatures in Industry. Anybody wishing to attend or requiring further information should write *as soon as possible* to the organizer of the conference : Professor Dr. A. Van Itterbeek, Naamsestraat 73, Louvain, Belgium.

Correspondence

Advantage of nuclear fusion as a source of energy

A question in the 1958 Graduateship examination asked " Why does nuclear fusion hold out more hope than nuclear fission as a general method of producing energy economically ? " The examiner's comments included the following " Few candidates mentioned that one of the advantages of nuclear fusion would be that there is no radioactivity problem." Both these statements require some examination.

The nuclear fission reactor is already sufficiently developed to rival economically other sources of energy under favourable conditions and the lines of future improvement are well understood. By contrast controlled thermonuclear fusion has yet to be demonstrated conclusively even on the laboratory scale, while the economics of a fusion power station are at present beyond calculation. Fusion fuel will be cheaper than fission fuel, but in existing reactors the capital charges are much more important than fuel costs, and the same will most probably apply to fusion systems. Of course the supply of fusion fuel is virtually unlimited whilst fission fuel will ultimately be exhausted, but this is purely a question for the remote future.

Fusion reactors will certainly raise problems of radioactivity, despite the absence of fission products. The reaction most likely to be used is that between deuterons. A large power station using this process will produce several hundreds of megacuries of tritium per year. This is admittedly only a soft β-emitter and it may be subsequently consumed in the T-D reaction, but the handling of large quantities of a gaseous radioactive material must raise problems. Further, the neutron production in these reactions is very much greater than that from fission. Hence coolants and structural materials used in fusion reactors may be expected to become more radioactive than those used in fission reactors.

It is to be hoped that no candidates were penalized for not agreeing with the examiner on these points.

J. W. Warren.

Brunel College of Technology,
London, W.3.

The examiner, Professor Lipson, comments :

I am grateful for the opportunity to reply to Dr. Warren's letter, not merely to deal with the specific point he raises but also to explain my attitude to this examination—" More Advanced Physics." When I was first invited to act as examiner my instinct was to refuse on the grounds of lack of ability ; but on second thoughts I considered that I might learn some physics in the process and I am glad now that I accepted. But no one, I think, can be expected to be expert on all the topics that can occur in this paper, and I do not think it necessary that they should be so.

All that is necessary is that the examiner should be able to recognize sound physics when he sees it. If an answer contains demonstrable nonsense (as I am afraid that many do) it is given poor marks ; if it contains as much as I myself know it is given reasonably good marks ; but if it contains more than I can judge and I have to check the reply against the textbooks (this has never happened yet) it is likely to gain very good marks.

In the light of these remarks I can now answer Mr. Warren's criticism. The question was " Why does nuclear fusion hold out more *hope* . . . ? " I still feel that this wording is vague enough for the candidate to have reasonable discretion in his reply. I certainly did not expect economic aspects to be dealt with.

With regard to the radioactivity problem, I was thinking of the disposal of radioactive waste, which is one of the major problems of fission procedures. If any of the candidates had brought to my notice the facts that are contained in Dr. Warren's letter, I should have been delighted.

Finally, the letter illustrates another point. If the Graduateship candidates could compress as much information into as small a space as Dr. Warren has done they would save themselves a great deal of trouble, they would help the examiners considerably, and they would save a large amount of paper !

The interpretation of the Special Relativity Theory

Professor Dingle, in his paper " The Interpretation of the Special Relativity Theory " (*Bulletin*, Vol. 9, p. 314, December, 1958) makes what seems to me to be a curious error.

He considers a point A at $x = 0$ in a system (x, t) and a point B at $x' = 0$ in a system (x', t') moving with velocity V in the positive x direction with respect to the first. A and B coincide at $t = t' = 0$, when light signals are emitted in both directions from the point of coincidence. P and Q are points whose x co-ordinates are permanently X and $-X$ in A's system. The co-ordinates (x, t) of the events which are the arrivals of the signals at P and Q are

$$(X, X/c) \text{ and } (-X, X/c) \qquad (1)$$

The co-ordinates (x', t') of the events are, by the Lorentz transformation

$$(X\beta, X\beta/c) \text{ and } (-X/\beta, X/c\beta) \qquad (2)$$

where $\beta = [(1 - V/c)/(1 + V/c)]^{\frac{1}{2}}$

This is agreed.

Dingle then writes " . . . the first beam has travelled a distance $X\beta$ (which is less than X) and the second a distance X/β (which is greater than X) by B's scale, while each has travelled a distance X by A's scale. Now the velocity of light is held to be c relatively to both A and B. Hence the difference of Q-readings requires that B's scale has contracted and the difference of P-readings that it has expanded, relatively to A's. But the existing theory requires that it has uniformly contracted ; whether the contraction is ' real ' or ' conceptual ' is immaterial here. Hence the existing theory needs amendment."

He subsequently writes " A and B cannot both remain at the centre of the light-sphere."

These arguments are fallacious because they overlook the fact that P has moved towards B and Q away from

B by the time the light reaches them. Thus, since according to relativity theory the dynamical addition theorem for the velocities of light and a moving screen apply to B's measurements, he naturally finds that the ray requires a greater t' (and x') to overtake the receding screen than to meet the advancing screen. It is quite erroneous to say that this difference indicates that B's scale is different in the two cases. Nor does the experiment contradict the statement that A has remained at the centre of his light sphere and B has remained at the centre of his. In fact it would be difficult to find a clearer illustration of that fact ; the events to which (1) and (2) apply occur on the wave front, and it may be seen at a glance that for all values of X the relations

$$\frac{|x|}{t} = \frac{|x'|}{t'} = c$$

are satisfied.

It must be concluded that if " the existing theory needs amendment " then it cannot be for the reason given in the paragraph quoted above.

M. R. Hopkins (*Fellow*).
Department of Physics,
University College of Swansea.

Professor Dingle comments :

Dr. Hopkins seems to have missed the point. I was not implying any strangeness in the fact that $X/\beta > X\beta$, i.e. that " the ray requires a greater t' (and x') to overtake the receding screen than to meet the advancing screen." Let me set out the argument in more detail.

(1) The expanding light-sphere is an objective thing —or a succession of objective things. The arrival of the light at any point (which may be marked, as in the case of Nova Persei, by a particle of a nebula, but this is not necessary) is an *event*. Its time and place may be estimated differently by different observers, but its space-time location is absolute.

(2) The wave-front for any observer is the locus of such events which occur at what he considers to be the same time. Different observers may differ as to what is the same time, but for each the wave-front is a locus of events.

(3) According to current relativity theory, the wave-front for each observer, A or B, is always a sphere centred at himself. The particular events which, at any of his instants, form a sphere for A do not form a sphere for B, and so are never B's wave-front. But at some instant in B's reckoning, his wave-front will pass through the Q-screen. B will then consider that the spatial distance between the events E_1 (emission of the light) and E_3 (arrival of the light at Q) is X/β whereas A considered that the spatial distance was X. There is no question here of B approaching or receding from the event E_3 : that is meaningless. Objects do not approach or recede from *events*, which are instantaneous, but from *objects*. If there were a screen permanently stationary with respect to B, which happened to be coincident with Q at the event E_3, then B would be neither approaching nor receding from it, but the space-time, space and time intervals between the events E_1 and E_3 would be exactly the same.

(4) These different estimates of the spatial distance between the same events in a series whose space-time separations are zero, are possible only if the measuring rods (and clocks) used by the two observers differ. In order that the distance which A measures as X shall be measured as X/β by B, B's scale must have *contracted* with respect to A's. Assuming that B is the moving observer and A the resting one, this is what current relativity theory asserts.

(5) Exactly the same argument applied to the P-screen requires that B's scale must have *expanded* with respect to A's. At some instant in B's reckoning, his wave-front will pass through the P-screen, B will then consider the radius of the light-sphere to be $X\beta$: i.e. he will consider that the spatial distance between the events E_1 and E_2 (arrival of the light at P) is $X\beta$, whereas A considered that the spatial distance was X. Since $X\beta < X$, B's scale must have expanded relatively to A's.

(6) Hence, owing to the relative motion of A and B, one half of B's scale contracts, and the other half expands, relatively to A's. This is contrary to current relativity theory, which requires that the moving scale, whichever it may be, contracts as a whole.

(7) Dr. Hopkins's misunderstanding becomes impossible if times instead of distances are considered. According to the theory, the event E_2 occurs earlier, and the event E_3 later, by B's clock than by A's. This cannot be confused with the fact that E_2 occurs before E_3 by B's clock alone.

The fallacy in physics

The first example cited by Dr. Maude in his interesting article on " The fallacy in physics and mathematics " in the December, 1958, *Bulletin*, recalls a difficulty which has perplexed me at intervals since the first artificial satellite was launched. Can any reader provide a satisfactory *physical* explanation of the mechanism whereby the effect of air resistance on such a satellite is to increase its velocity through the air ? It is easy to see why the effect occurs, but not so easy to see how it occurs.

Presumably similar difficulties occur if one inquires too closely into the orbital velocities of electrons on the Bohr model, but we have become accustomed to accepting only " mathematical " explanations of phenomena on this scale. Are there any other examples and explanations of this apparently anomalous effect of a dissipative force on a macroscopic scale ?

A. E. De Barr (*Fellow*).
The British Cotton Industry Research Association,
Manchester, 20.

Reviews of Books

OUR NUCLEAR FUTURE, FACTS, DANGERS AND OPPORTUNITIES

By Edward Teller and A. L. Latter

London : Martin Secker & Warburg Ltd. Pp. 184. Price 21s.

This book is stated by the authors to have been written " for the layman who has no knowledge about atoms, bombs and radioactivity." It might have had as its sub-title " Theme and Variations." The theme is *reassurance*, the variations are numerous, and one might add that the treatment is often naïve. Thus, on the first page, we are told that against the fears which haunt mankind to-day we have only two weapons, " understanding and courage," it being clear from the context that by the former is meant mere *technical appreciation* of present-day scientific developments. The suggestion is that with sufficient scientific enlightenment and the courage to take risks, progress will be assured, and our difficulties will vanish. One would have thought that the kind of optimism thus implied belonged to the nineteenth century rather than to the middle of the twentieth, but it is characteristic of the brave new world envisaged by the authors.

The " reassurance " theme is evident even in the technical introduction (the first 80 pages approximately), which otherwise serves its purpose well enough. Thus (p. 17) we read " We are therefore in a position to put before the reader the most important facts about the peaceful and military applications of nuclear energy—of the possible dangers and of the eventual benefits. If we do not succeed, we cannot blame either secrecy or the difficulty of the subject. It is true that the subject is involved, but only in the same way as are those subjects of everyday experience with which all of us have to struggle once in a while. No greater intellectual effort is needed than is involved in the understanding of the income tax form or the racing form, to mention two analogies of rather diverse emotional content. Many of the ideas will be unfamiliar, but they are not complex." Again, we are told (p. 22) that " The atom has been explained as completely as Newton has explained the motion of planets " ; but ought we not to add " and as incompletely " ? For such a statement, unqualified, is grossly misleading to the layman. Even Teller and Latter say (p. 81), of the details of the nuclear explosion, " we understand only a small part of the process."

But it is in the second half of the book (dealing largely with weapons and weapon tests) that the " reassurance " theme is sounded most bravely. This section begins with a graphic account of bomb testing, which is followed by a discussion of the 1954 fall-out accident. Here it is difficult to avoid the conclusion that the consequences of the latter for those involved (including the Japanese fishermen) are carefully minimized, though it is admitted that long-term effects still need to be watched for. Again and again in this part of the book the phrase " the big bombs " occurs, an expression which, in its context, seemed to the reviewer to have the same ring about it as " the big cats," the term of affection used by lion tamers for the monsters over which they spend their lives trying to retain the mastery. Perhaps there is a clue here, and a warning.

Chapters follow on the fall-out hazard, with special reference to Cs^{137} and Sr^{90}. Here also, an otherwise reasonable discussion is marred, this time by sudden outbreaks reminiscent of Orwell's " double-think." Thus (p. 115) there is a passionate plea for so-called " clean " bombs as " most desirable," for considerations of " respect for human life," " military necessity " and " simple sanity." Again, on page 119 it is stated that " actually there can be little doubt that radiation hurts the individual cell. But a living being is a most complex thing. Damage to a small fraction of the cells might be beneficial to the whole organism " ; yet, on page 162, in explanation of the very large radiation doses which are required to sterilize food, compared with the relatively small doses which are lethal to complex organisms, we read " small organisms may escape the radiation effects by mere chance. On the other hand a big and complicated organism will cease to function when the most sensitive among its essential tissues have been destroyed": confusing to the lay mind, to say the least of it. Statistical treatment is applied (consciously or unconsciously) to the all-important end of reassuring the reader. For example (p. 120), it is calculated (on the basis of a linear dose-effect relationship) that the bomb tests to date may be responsible for perhaps 10,000 cases of leukaemia and bone cancer in the next generation. But this figure is promptly added to the 6,000,000 cases which will occur " naturally," and it is then written off because (statistically) " There is no way to differentiate between the fall-out-induced cases . . . and those which occur naturally." The point is driven home on page 124 where we read " We may summarize in this way. Our knowledge of the effects from the fall-out is deficient. We cannot say exactly how many lives may be impaired or shortened. On the other hand, our knowledge is sufficient to state that the fall-out effect is below the statistically observable limit." This ability to lose sight of the individual behind a statistical smoke screen or a sufficiently large number of ciphers seems to the reviewer one of the most tragic elements in modern thought.

Some statements on certain aspects of the current situation are misleading, whether through ignorance of the facts, or otherwise, is difficult to say. Thus, on page 140, we read that nuclear explosions " can be effectively hidden if appropriate care is taken to hide them. There can be no doubt that this is possible." Whilst it must be admitted that this was written before the findings of the Geneva conference on this subject, it is hard to believe that any evidence available to that conference was not also available to the authors of this book a few months earlier. Again (p. 124), it is stated that " the danger from the world-wide fall-out is less than many other radiation effects which have not worried people and do not worry them now," the context indicating that the " radiation effects " referred to include medical radiology. Here it is fair to comment

that it all depends on who is deemed to be unworried : the people at the receiving end of medical X-rays are not worried, in general ; *but the people who administer them are.* Thus, for years, the radiological literature has been spattered with an increasing number of papers on protection against radiation hazards and the minimization of the radiation exposure of patients, representing an ever-growing concern which, in Britain, has culminated in the present activities of the Adrian Committee. In this connection, it is as well to remember that over roughly the last decade the so-called " maximum permissible dose " to radiation workers has been reduced by an order. Could this be said to substantiate Teller and Latter's contention, or are they trying to say that the medical profession is worrying over trifles ? The truth is, of course, that where there is ignorance one proceeds with caution ; but first one must be able to admit one's ignorance. It is with the medical applications of atomic energy that the reviewer is most familiar, and so it was in this connection that any lack of authenticity was most easily detectable : thus the definition of the röntgen given in the Glossary is essentially that of the rad ; the older figure of 32 rather than the currently accepted value of 34 eV/ion pair is given in the text ; the reason given for the selective action of radiation on cancer cells (p. 122) is that " some cancer cells are more strongly damaged by radiation than the normal cells " (a misleading statement) ; treatment based on " radioactive destruction of diseased tissue " is described as " new " (p. 161), whereas in reality it dates back to within a few years of the discovery of radium ; whilst on the same page, reference is made to " a safe radiation dose," surely a dangerous concept. These are all small matters in themselves, but suggest that the text does not represent as rigorous a treatment as one might have expected from such authors.

The final chapters, in which are discussed the political and moral aspects of the situation created by the advent of nuclear weapons and nuclear energy, are characterized by a superficiality which leads to such sweeping assertions as : " no reasonable person will advocate unilateral disarmament " (there are many reasonable, and indeed famous, men and women who advocate just this) ; " in the Second World War strategic bombing was used for the first time on a really massive scale. It may well be and, in fact, it is probable that such strategic bombing will not be repeated in the future " (what possible justification is there for such a statement ?) ; " the certainty of a counter blow gives real protection against all-out war " (again, what is the justification for the statement ?) ; " if we renounce nuclear weapons we open the door to aggression " (the implication being that the alternatives are simply the possession of nuclear weapons or their renunciation, a gross over-simplification). Yet, despite all this, there are to be found dotted here and there throughout this later part of the book, and looking strangely out of tune with the rest, much more worthy sentiments : " some proper form of international responsibility will have to be developed " ; " knowledge will lead to disaster if it is not tempered by wisdom " ; " our guarantee is the better and saner part of human nature ; the will to survive and the feeling of common decency." What a pity that faith " in the better and saner part of human nature " was not the theme of, rather than the contrasting discords in, this inharmonious composition !

L. A. W. Kemp.

VACUUM-TUBE AND SEMICONDUCTOR ELECTRONICS

By J. Millman

London : McGraw-Hill Publishing Co. Ltd. Pp. ix + 644 Price 77s. 6d.

This book is written to cover the first year of a course in electronics for undergraduates studying electrical engineering. It deals with the basic physics of vacuum, gas-filled and semiconductor devices, and with circuit theory, emphasizing in this connection the role of the devices as circuit elements. Much of the material parallels and some is drawn from the earlier well-known text on *Electronics* by Millman and Seely, the new matter, of course, being mainly that relating to semiconductors.

One of the objects of the book is to integrate vacuum and semiconductor devices, and with this in mind the sections on diodes, photoelectric devices and triodes each deal first with vacuum tubes and then with p-n junction diodes and transistors. A similar arrangement follows when the devices reappear as circuit elements. Only semiconductor devices containing p-n junctions are included, but these are discussed very thoroughly.

The integration might perhaps have been pushed further in relating discharges in gases with corresponding effects in solids ; the analogy between breakdown in the two cases is mentioned but not developed, and more might have been made of the correspondence between the recombination processes in the two cases, and between storage time and deionization time ; there is no mention of the relatively recent developments leading to solid-state analogues of the thyratron. These are, however, minor points, and the book can be thoroughly recommended as a source of reliable information, well co-ordinated, well presented and lucidly written. The problems at the end provide stimulating exercises for the student.

D. A. Wright.

An INTRODUCTION TO RADIATION COUNTERS AND DETECTORS

By C. C. H. Washtell

London : George Newnes Ltd. Pp. xii + 115. Price 21s.

Mr. Washtell has set out to supply basic information to workers in scientific fields other than physics, who are faced with using counting devices for the first time. The largest sections of the book deal with geiger counters and scintillation counters. Rather less space is devoted to ionization chambers and proportional counters with a brief mention of instruments such as spark counters and cloud chambers.

In this book the emphasis is placed on the details of construction of the various counters rather than the physical principles on which they are based. For example, 14 pages are devoted to a comprehensive list (giving sizes, working voltages, etc.) of commercially produced Geiger and proportional counters. This table,

and others like it, will be useful for reference purposes. On the other hand, the constructional details are given such prominence that the non-specialist reader may find difficulty in appreciating the considerations which lead to the selection of a particular device to do a certain job.

A very short chapter at the beginning, on atomic structure, and another at the end, on dosimetry and radiation protection, are too brief to be of any practical use. The space might have been more profitably employed in expansion of the main subject matter. The diagrams are excellent. They are simple and yet contain all the necessary information. In addition to these 36 line drawings the text is illustrated by 12 plates.

J. M. VALENTINE.

MECHANICAL RESOLUTION OF LINGUISTIC PROBLEMS

By A. D. Booth, L. Brandwood and J. P. Cleave

London : Butterworth's Scientific Publications. Pp. vii + 306. Price 50s.

Computers were first regarded as mathematical tools, and are used as such in many currently established procedures in science and technology. There is now a growing appreciation that more fundamentally they are logical tools, and that there are (or should be) many other rewarding fields for applied logic. Applications to commerce, bibliography and strategic conflict have been recognized and in some cases achieved ; other and more exotic fields are now being envisaged.

This book deals with linguistic problems, in relation to work actually being performed at Birkbeck College. At one extreme is the relatively straightforward requirement of producing concordances and statistics bearing upon literary style, at the other the question of automatic and idiomatic translation between standard languages. Intermediately there are translation problems where the "languages" are in effect the Latin alphabet and systems of using Braille characters ; non-standard languages are also implicitly involved in non-idiomatic translation requiring editorial intervention to modify word-order and the like.

Achievements in speed and storage capacity in present and projected computers may well be considered remarkable ; even so, satisfying a few simple requirements will readily put problems far beyond their grasp. A first requirement would be to increase the bulk of material requiring simultaneous storage (the simplest way is by permutations and combinations readily defined in colossal volume from a mere handful of basic data), and then to require random access to the stored data ; this is what makes computers still mediocre rather than master players of chess. A second requirement is to complicate the decision problems by a mass of illogically related particular cases and exceptions ; this is the difficulty with many commercial applications.

The full translation problem goes far to satisfy both requirements ; consideration of a large vocabulary is extended in combinatory fashion by questions of inflexion, word-order, context and idiom, and additional complications arise from ubiquitous monuments to human unreason in the form of unnecessary and often irregular inflexions and constructions.

The task of the philologist, as now of the translation-machine constructor and programmer, is basically to reduce this material to a logical system based on as few categories and dichotomies as possible. Some idea of what this involves can be gathered from this book.

Compression by use of Braille digraphs is readily met by simple programming ; what causes trouble is securing that in some circumstances digraphs are not to be used—e.g., with "θ" for "th," we are allowed "baθ" but not "boaθouse", in effect. Does this matter ? It is all right when human operators can do it ; is it not a gnat rather than a camel if (as it may well) it makes the difference between feasible and non-feasible machine procedures ?

Similarly with translations : an imperfect but adequate rendering on the desk is better than a perfect translation not yet available. Economic considerations may thus force the use of more or less imperfect translations, and these may in turn feed back to modify linguistic usages. The best is the enemy of the good, and information theory now gives a retrospective justification for pidgin English.

The book itself has both the merits and the defects of a pioneer work. There is much material not otherwise available or collected, obviously hastily assembled and consequently not organized to best advantage. It would be better to assume some familiarity with machines (abundant references are possible), rather than to attempt a basic description at the price of relegating discussion of actual programs to a related companion volume.

Chapters of only fifteen and five pages on French and Russian are separated by a 162-page chapter on German, apparently attributable to one of the nominally junior authors. This chapter occupies more than half the book, and would be better dissociated from the rest, as an appropriately titled self-contained work ; it could serve as a model of what is required for other languages, and has much to offer to the ordinary student of German, unconcerned with mechanical translation.

T. H. O'BEIRNE.

PRINCIPLES OF STATISTICAL TECHNIQUES

By P. G. Moore

London : Cambridge University Press. Pp. viii + 239. Price 22s. 6d.

This book is intended as "a first course, from the beginnings, for schools and universities." The contents list of the first half (104 pp.) follows a familiar pattern. Beginning with the collection, tabulation and graphical representation of data it progresses to the various measures of distributions. On reading the pages, however, there is evident a certain freshness of treatment perhaps brought about by the wider than usual variety of the examples. The introduction demonstrating the need for the subject and the treatment are very full and detailed, and thus suitable for school use.

The last seven chapters lead smoothly on from the first half of the book (this division made for the purpose

of review does not correspond to a real one in the book) and get down, unlike many elementary books, to the application of statiistical methods.

The chapter on Probability and Sampling introduces inference without any emphasis or formal treatment ; inference appears as the obvious way to answer one of the examples. This introduction of the idea solely through example is one of the features which teachers in schools would find of value.

Tests of significance, time series and association are dealt with in the remaining chapters.

Like many other books of this standard the mathematics required is given as that of the ordinary level G.C.E. but here, as elsewhere, this is solely because of the need to use the binomial expansion. Fully explained as it is in this book the subject could be tackled by those with even less mathematics.

Although the undergraduate may find it a useful introduction it is doubtful whether it could form the basis for a course of university standard.

E. D. van Rest.

HEAT—TO ADVANCED AND SCHOLARSHIP LEVEL

By A. J. Woodall

London : The English Universities Press Ltd. Pp. xii + 373. Price 21s.

This is another textbook in the series published under the general editorship of Sir Graham Sutton and originating from the Royal Military College of Science, Shrivenham. The present volume is a worthy member of the series which has a refreshing vigour in its approach. It contains the material needed for the Advanced and Scholarship level in Heat of the British Examining Boards and examinations of similar standard.

The presentation is fresh, realistic and comprehensive. Care has been taken to use illustrations which the student will meet in his daily life, and there are many welcome references to, and links with, the other sciences. These help to make the book of real value in the education of the student, and serve to enhance his interest in the world around him. They have not, however, made the book any less rigid in its treatment of the physics, but throughout effort has been made to ensure a commonsense approach to a problem, with a minimum of rules and formulæ. The emphasis is on physical principles, and the deductions that can be made from them ; the student is stimulated to think clearly. There are realistic details introduced into accounts of standard apparatus and useful tips for carrying out the usual laboratory experiments.

The historical development of the subject matter is touched on throughout the book and at the end a short chapter is devoted to it. This, as the author says in his preface, is made desirable, particularly in a textbook on Heat, by the sometimes archaic and misleading terminology. There is a wealth of diagrams which may strike some readers as being too small, but size was presumably decided with reference to the price of the volume.

This book is to be strongly recommended for its main purpose but would not seem to serve nearly so well its secondary purpose, which is to provide a text for students of the humanities making limited studies into selected scientific subjects.

Kathleen E. Parks.

THE UNIVERSE

London : G. Bell and Sons Ltd. Pp. xvi + 142. Price 13s. 6d.

It seems a pity that the manner and style of production of this book of essays are so far below what is expected of even popular astronomy nowadays ; for the essays, although brief, are clear and contain a great deal of usefully condensed information about galactic and extra-galactic observation and speculation. The contributions by the great masters of observational cosmology, Baade, Minkowski, Jan Oort, Martin Ryle, are on the whole the best, and Dingle plays his well-known and valuable part in warning that speculation must not wear the cloak of knowledge. But Hoyle's short account of steady-state theories raises shrewdly more problems than the same number of pages have perhaps ever propounded before, and with a clarity as to the alternatives which deserves the highest admiration. The genius of Gamow for devising simplified diagrams is shown at its best, but many of the other diagrams through the book are over-simplified ; so the work could be misleading unless it sends its readers to original sources.

Martin Johnson.

A STRUCTURAL INTRODUCTION TO CHEMISTRY

By E. T. Harris

Glasgow : Blackie and Son Ltd. Pp. ix + 181. Price 12s. 6d.

It is not easy to decide for whom exactly this little book is intended. The Preface seems to suggest that the author's aim is to provide " a simple but accurate introduction to Chemistry . . . [for] the general body of educated mankind." But the level of the exposition is very uneven. The first chapter and some later sections would seem suitable for extramural adult classes but, in reading the book as a whole, one feels that the I.Q. of the reader whom the author has in mind is decidedly variable. This is not a question of the reader's acquiring information as he proceeds, but rather of widely fluctuating levels of argument. Compare, for example (p. 3), " The molecules [of a gas] are perfectly elastic, far more elastic than a rubber ball. If a rubber ball is dropped, it bounces to about three-quarters of the height from which it was dropped . . ." with (p. 64) " . . . the unshared electron in the single-occupied *p*-orbital . . . is drawn towards the electron with which it pairs on the other atom, while electrons in doubly-occupied orbitals (3*s* and 3*p*) are pushed away from the bond by the repulsion of like electric charges."

Moreover, the subject matter is badly arranged. Terms and ideas which are carefully explained in one place are referred to much later as if they were complete strangers. Only two examples can here be cited : the nature of molecular polarization, p. 165, cf. p. 69 ; and free radicals, p. 167, cf. p. 142.

If the author would prepare a second edition of this little book bearing these points in mind, rearranging his material with a more ordered sequence and reducing

the standard deviation of what might be called the " stiffness factor," we should have a most valuable book. A really concise account of modern views on the nature of chemical bonds, together with some glimpses of electro- and organic-chemical theory, is indeed a boon to physicists and others not trained in chemistry or, like your reviewer, trained long ago.

Two smaller points are worth noting for future editions. While it is true that Dalton's atoms were very different from those described by Lucretius, it should be mentioned that atomism did exist before 1802 ; and secondly, one wonders why the Table of Contents was evidently designed in such style and format as to present the greatest possible difficulty to the reader looking for something in a hurry.

G. W. Scott Blair.

ADVANCED LEVEL PHYSICS

By M. Nelkon and P. Parker

London : W. Heinemann Ltd. Pp. x+1057. Price 30s.

This book is written in a clear, simple style, is well illustrated and contains many worked examples and collections of exercises. It can be recommended to students reading physics for Advanced level G.C.E. and Scholarship level. The approach is conventional though several new ideas in presentation and subject matter are included, especially in the sections on heat and on electricity and magnetism.

The writers are obviously experienced teachers who have given much thought to the presentation of their subject. Nevertheless, minor criticisms of the text may be put forward. On introducing the concept of mass, the too early statement of Einstein's mass-energy relationship in an attempt to be modern in outlook would confuse a student at this level. The section on " centrifugal force " (a somewhat misleading though convenient term) could be extended and more carefully phrased ; it is well known that beginners often gain erroneous ideas in this context. In the account of surface tension, the fact that the unit is the dyne per cm. could be more clearly related to the preamble on the molecular theory. The good discussion of osmosis would be improved if the order of *size* of the water and solute molecules were mentioned in relation to their passage or otherwise through a semi-permeable membrane. As in similar text-books on Advanced level physics, it is a pity that accounts of the camera are not more extended and modernized, particularly in view of the interest of most students in photography. In the chapter on " photometry " a simple account of the modern units would be valuable, even though they are not mentioned in syllabuses. The account of the action of a dielectric is better than in most text-books at this level, but it might still be improved. Students rarely understand properly the reason why an increase of capacitance results on replacing air by a solid dielectric like mica, so the account given (unfortunately in smaller type) should be enlarged and perhaps more carefully worded.

To offset these criticisms, topics especially well discussed deserve mention. These include the welcome section on meteorology, the account of optical instruments, details given of the determination of the velocity of light, the description of the dip-circle, the chapters on changes of state and on electrostatics, the useful inclusion of an account of universal meters, the excellent description of the potentiometer (like the reviewer, the authors have obviously found that many students do not appreciate fully this important device), the description of the Wheatstone bridge, the chapter on the chemical effect of a current, and the section on magnetic materials.

In optics, the sign convention chosen is " real object or image distance is a positive distance " and " virtual object or image distance is a negative distance." The reviewer prefers the Cartesian convention because it is more in line with practice encountered in post-Advanced level texts. In electricity and magnetism, traditional units are used. This would seem a sound policy, even though it is out of line with post-Advanced level texts, especially those in engineering. This contrariness of the reviewer's opinion is based on the presumption that, whereas it is not difficult to teach optics using a Cartesian sign convention, experience indicates that it is quite difficult to teach electricity at an elementary level to the average student if m.k.s. methods are employed.

J. Yarwood.

TRAINING AND OPPORTUNITIES FOR WOMEN IN ENGINEERING

By Vera Holmes and Lesley S. Souter

London : The Women's Engineering Society. Pp. 42. Price 3s. 6d.

This booklet is a revised and enlarged edition of *Engineering Training for Women* which was published by The Women's Engineering Society in 1955.

The General section reviews the methods of training for professional status and the courses that are available. In the remaining sections dealing with opportunities of employment particular attention has been paid to those branches of engineering in which women are most readily accepted ; details of special training facilities are included.

The arrangement of the contents is rather confused, and in places the text is carelessly presented and inaccurate (the full title of the Dip. Tech. is given almost throughout as the Diploma of Technology). Nevertheless, the booklet provides a great deal of useful information and a well-balanced view of the prospects for women in the engineering profession.

Jean B. M. Bowers.

Forthcoming Institute Meetings

Date	*Place*	*Speaker*	*Title*	*Time*	*Branch or Group*
Feb. 16	**Manchester** The University		Branch Annual General Meeting followed by a talk on :	6.30 p.m.	Manchester and District
		Prof. E. C. Cherry (*Imperial College of Science and Technology, London*)	**The origins, ideas and applications of information theory**	7.00 p.m.	
Feb. 17	**London** The Institute's House	Dr. S. Kaufman (*Associated Electrical Industries Research Laboratory, Aldermaston*)	**Experimental observations of a highly ionized gas**	5.30 p.m.	Electronics
Feb. 18	**London** The Institute's House	Prof. J. D. Bernal, F.Inst.P., F.R.S. (*Birkbeck College, London*)	**The theory of liquids**	6.00 p.m.	London and Home Counties
Feb. 20	**London** The Institute's House	Mr. F. W. J. Garton, A.Inst.P. (*United Kingdom Atomic Energy Authority, Research Group, Woolwich*) Mr. R. A. Mostyn (*Chemical Inspectorate, Ministry of Supply, Woolwich*) Dr. R. L. Mitchell, (*Macaulay Institute for Soil Research, Aberdeen*) Mr. M. Ward, (*Pilkington Brothers Limited, St. Helens*) Mr. G. Kingsbury (*Chemical Research Laboratory, Teddington*) and others.	A Colloquium on **Spectrochemical analysis of powders**	3.00 p.m.	Applied Spectroscopy
Feb. 24	**Edinburgh** The University	Dr. L. R. G. Treloar, F.Inst.P. (*British Rayon Research Association, Manchester*)	**Rubber and the rubber-like-state**	7.15 p.m.	Scottish Branch
Feb. 25	**Dundee** Queen's College	Dr. L. R. G. Treloar, F.Inst.P. (*British Rayon Research Association, Manchester*)	**Rubber and the rubber-like-state**	5.00 p.m.	Scottish
Mar. 3	**Glasgow** The University	Prof. E. R. Andrew, F.Inst.P., F.R.S.E. (*University College of North Wales*)	**Recent advances in nuclear magnetic resonance**	7.15 p.m.	Scottish
Mar. 4	**Aberdeen** Marischall College	Prof. E. R. Andrew, F.Inst.P., F.R.S.E., (*University College of North Wales*)	**Recent advances in nuclear magnetic resonance**	7.15 p.m.	Scottish
Mar. 4	**London** The Institute's House		Group Annual General Meeting	5.00 p.m.	Education
		Mr. C. A. Ronan, (*The Royal Society, London*)	**Some aspects of the international geophysical year**	6.00 p.m.	
Mar. 6	**Bristol** The University		Branch Annual General Meeting	6.15 p.m.	South Western
		Prof. C. B. Allsopp, F.Inst.P. (*Guy's Hospital Medical School, London*)	**Physics in the investigation of crime**	7.00 p.m.	
Mar. 11	**Leeds** The University	Mr. H. W. French, F.Inst.P.	Branch Annual General Meeting followed by a lecture on **Physics and musical syntheses**	5.00 p.m.	Yorkshire
Mar. 12	**Liverpool** The University	Mr. O. W. Humphreys C.B.E., F.Inst.P. (*Research Laboratories of The General Electric Co. Ltd., Wembley*)	**The impact of research on industrial economy**	7.00 p.m.	Liverpool and North Wales

Obituaries

F. Ashworth (*Fellow*)

It was after only a very brief illness that Fred Ashworth, Ph.D., A.M.I.E.E., F.Inst.P., died last November, at the age of 39 years. After graduating at Liverpool University, Dr. Ashworth joined the Metropolitan-Vickers Electrical Company in 1940, and following a period of training worked in their Research Department as a physicist. From 1945-1947 he carried out research on field emission microscopy at Bristol University under a Metropolitan-Vickers scholarship. He then returned to the same company and continued to work on field emission. In 1951 he took charge of a team working on various problems, including the vacuum evaporation of materials to form hard coatings, and the behaviour of arcs in evacuated enclosures. Later he also took charge of investigations in electron microscopy and electron diffraction. He gave various lectures and papers to The Institution of Electrical Engineers and to The Institute of Physics (which he had joined as an Associate in 1942) and at various times took part in the activities of each of these bodies. For some years he had been a member of the Electronics Group Committee of the Institute. He will be remembered by numerous friends for his keen sense of humour, his interest in winter sports, and for the ski trips which he and his wife, Rita, jointly organized over several years.

The sincere sympathy of his colleagues and friends is extended to his widow and two children in their bereavement.

R. W. Sillars.

E. G. Godfrey (*Associate*)

Mr. E. G. Godfrey died after a sudden heart attack on December 2, 1958, at the age of 51.

Eric Godfrey obtained his degree in physics at Kings College, London, after studying under Prof. E. V. Appleton as he then was. After some ten years of industrial experience in telephone laboratories and works, he entered technical teaching service at the Woolwich Polytechnic. He came to the Borough Polytechnic as a Lecturer in Physics and Telecommunications in 1950. He was a keen and popular worker in the cause of higher technical education with service on the Regional Advisory Council and the Association of Teachers in Technical Institutions (A.T.T.I.) of which he was a Past President. His many friends and associates join in conveying their heartfelt sympathy to Mrs. Godfrey and her two young children.

S. N. Ray.

The Institute's Journals

PRINCIPAL CONTENTS OF THE FEBRUARY, 1959, ISSUES

Journal of Scientific Instruments : Volume 36, No. 2

Nuclear spin pulse apparatus. By K. Luszczynski and J. G. Powles.

A detailed description including circuits and operating instructions, is given for the construction of a nuclear spin pulse apparatus which will measure nuclear spin-lattice relaxation times from 500 μs upwards and nuclear spin-spin relaxation tmes from 20 μs upwards over the temperature range −180°C to +220°C with an accuracy of better than ±5%. An Appendix lists where all published circuit diagrams and technical data suitable for spin echo apparatus may be found.

Wide range recording anemometer. By A. N. Rapsey, Grad.Inst.P.

The anemometer described uses optical linkages to measure wind speeds from 2 to 100 miles/h and wind direction to within ±2°. The output is in the form of pulse-modulated signals suitable for counting directly or for recording on magnetic tape.

Two emission stabilizers for electron-bombardment furnaces. By D. Allenden.

Stabilization requirements and techniques for electron-bombardment heating are considered, and basic design formulae are presented for a flexible control system applicable to temperature-limited emission furnaces. Power handling capacity, loop stability and speed of response are discussed, and full circuit details of practical stabilization systems for a 250W and a 6kW furnace are given. It is concluded that

emission stabilization is always beneficial, and sometimes essential, and that emission stabilities of better than 0·5% at powers up to 20 kW are practicable.

Three-beam interferometer. By P. Hariharan, A.Inst.P., and D. Sen.

The instrument described utilizes a beam dividing system similar to that used in the Jamin interferometer, but employs three interfering beams instead of two. This permits the determination of the fractional fringe order with an extremely high degree of accuracy. It can be used for studying very small changes of refractive index in gases and liquids, and, in a slightly modified form, as an auto-collimating interferometer for the precise measurement of the thickness of evaporated films.

Photoelectric setting methods for a three-beam interferometer. By P. Hariharan, A.Inst.P., D. Sen and M. S. Bhalla.

Some of the photoelectric methods which can be applied to estimate the fractional fringe order in the three-beam interferometer described in the preceding paper are outlined, and their comparative merits are discussed. Experimental measurements show that with the help of such methods settings can be repeated to better than $\lambda/1000$, provided care is taken to minimize temperature fluctuations.

Mechanical structure-factor computer. By Prof. W. Schaffer.

The construction and use of a machine for computing sums of sine and cosine series, such as those required for structure factors in crystallography, is described. The machine is entirely mechanical and carries out the whole computation. It saves about half the time usually taken and is sufficiently accurate for most purposes.

A liquid manometer with electromagnetic balance indicator. By J. F. Kemp.

The paper describes the construction and operation of a null-reading type of liquid manometer, which utilizes an electromagnetic device for balance indication, and a set of analytical weights for indirect " weighing " of the unknown differential pressure. The apparatus was designed specially for measurements in the range of differential pressures below 5 mm water gauge. The probable error under laboratory conditions was found to vary from less than 0·01 mm water gauge at maximum range, to about 0·0005 mm water gauge at a differential pressure of 0·01 mm water gauge. Apart from its normal applications as a manometer, the apparatus can be used as an indicator of the flow dynamic head in low-speed wind-tunnels.

Two-layer anti-reflexion coating for low refractive index glass. By L. Holland, F.Inst.P., and T. Putner, Grad.Inst.P.

A method is described for producing durable two-layer anti-reflexion coatings on low refractive index (approximately 1·5) glasses. Practical difficulties in evaporating absorption free films of high index materials are avoided by reactively sputtering a bismuth oxide film which is then coated with an evaporated magnesium fluoride film. The initial oxide layer is prepared by sputtering bismuth in oxygen from sector-shaped cathodes placed under a rotary holder, and the magnesium fluoride is evaporated in sequence from a vapour source arranged under the edge of the rotary holder. To reduce the reflectance of a glass ($n = 1·5$) at a specified wavelength in the visible region, the bismuth oxide is deposited until the glass reflectance has risen to 8% and the magnesium fluoride evaporated until the reflectance falls to a minima ($R < 0·1\%$). Curves are given for the reflectance of the two-layer coating in the visible region. A simple method of monitoring the wavelength of the reflectance minima is described. It is shown that the wear resistance of the two-layer coating is equal to that of a single-layer magnesium fluoride film and is improved by baking at 250°C.

Continuous reading balance for oxidation studies. By E. Dempsey.

An instrument designed for studying the oxidation behaviour of a toxic radioactive metal is described. The mode of suspension, consisting of a crossed spring arrangement, while being very robust, permits the detection of mass changes of 50-100μg. in an initial specimen mass of 1-2g.

Thermostat suitable for controlling air temperature, particularly in biological research. By J. W. L. Beament and K. E. Machin.

Some of the features essential to the control of air temperature in small and unlagged containers are outlined, and apparatus is described which will control the temperature in such a container to $\pm 1/50$°C. A system of continuous proportional control is used, based on a two-stage directly coupled amplifier whose input is dependent on the resistance of a thermistor, and whose output is fed directly to the heating element. Incorporation of variable positive feedback makes it possible to attain high sensitivity, or alternatively to use the equipment without modification as a switching thermostat and electronic relay for large power loads. A description is also included of a temperature-measuring system based on a thermistor, which will display the air temperature to $\pm 1/50$°C.

Electron bombardment apparatus for vacuum evaporation. By J. C. Kelly, Grad.Inst.P.

Simple experimental arrangements are described for the evaporation of tantalum and zirconium from a pendant drop, maintained molten by electron bombardment. The method is clearly of general application and has advantages over existing techniques. Since there is no boat or container there is no possibility of solution of the boat material and consequent contamination of the evaporant. The material to be evaporated is used in wire or rod form ; these may be very easily interchanged.

Recording optical lever. By R. V. Jones, F.Inst.P., and J. C. S. Richards.

A small optical lever is described which can detect a change of 10^{-10} rad in orientation of a 2 mm^2 mirror, with a response time of about 0·25 s. A differential cadmium selenide photocell is used with a standard optical grid technique to detect the displacement of the reflected light beam from a 4 V 3·2 W lamp. Transistors are used to stabilize the lamp current and to amplify the signals for a pen recorder. "Noise" arising from convection currents in the light beam and from the photocells appears not to exceed greatly the photon fluctuations in the light beam. Records illustrate the performance of the lever and amplifier in detecting changes in dimension of a crystal of a few times 10^{-10} cm and changes in refractive index of a gas by a few times 10^{-9}. The system has also been applied to an infra-red detector using the linear expansion of a metallic strip, where the limit for a $5 \times 0·2$ mm strip is about 10^{-11} W for a 1 c/s bandwidth. For this purpose the signal can be differentiated with respect to time, and velocities of down to 30 μ/annum can be observed. It appears that a displacement of 10^{-12} cm could be detected.

Evaporation of metals by electron bombardment. By O. S. Heavens, F.Inst.P.

The rate of deposition of films of several metals, evaporated by maintaining a pendant molten drop by electron bombardment, is found in most cases to agree with that expected on kinetic theory. The analysis enables the usefulness of the method for other metals to be judged.

British Journal of Applied Physics : Volume 10, No. 2

Counter diffractometer—The theory of the use of centroids of diffraction profiles for high accuracy in the measurement of diffraction angles. By E. R. Pike, A.Inst.P., and A. J. C. Wilson, F.Inst.P.

The high resolution of the diffractometer, together with its ability to measure intensities accurately, allows the whole profiles of the diffraction lines to be studied. The width of the profiles is dependent on the spectral width of the characteristic radiation and on the geometry of the instrument. It is shown theoretically that the true Bragg angles can only be found, for work of the highest accuracy, from the centroids (first moments) of the profiles, the mathematics required to correct the peak positions being prohibitive. Experimental procedures required to put this theoretical advantage of the centroid into practice are explained, and difficulties due to the slow decay of the tails of the lines, and the uncertainty of background level are circumvented. An expression for the uncertainty in the centroid, found by step-by-step scanning by the fixed-time technique, due to counting statistics, is derived. This is plotted for the case of a single Cauchy profile. It is found that this uncertainty depends greatly on the peak-to-background ratio, and hence that scintillation or proportional counters have a marked advantage over Geiger counters for this type of work. It is concluded that, when the maximum accuracy in lattice-spacing measurements is desired, the centroid must be used instead of the peak, and that this does not involve excessive inconvenience in practice.

Effect of temperature and moisture content on the orientation produced by the drawing of nylon 66. By C. G. Cannon, F.Inst.P., and F. P. Chappel, A.Inst.P.

Increase in moisture content or ambient temperature up to about 165°C, increases the maximum extension obtained by drawing nylon 66 filaments and the resulting orientation of the molecules due to their increased mobility. Above 160°C disorientation due to thermal energy offsets this, and lower birefringences were observed for a given extention. The results are consistent with adiabatic drawing at a neck up to a natural draw ratio determined by the ambient temperature, combined with isothermal drawing uniform along the length of the specimen.

Thermionic properties of thorium deposits on control grid materials. By J. A. Champion, A.Inst.P.

Experiments are described in which the emission is measured from thin films of thorium deposited on different platinum-molybdenum phases of approximate composition Pt, Pt_3Mo, Pt_2Mo, Pt_3Mo_2 and Mo. The emission from all the platinum phases is considerably lower than that from pure molybdenum. The lowest emission was observed with the Pt_3Mo phase. The emission from thorium deposited on to the Pt_3Mo_2 phase decays rapidly at temperatures of 1300°C and above, whereas that from similar deposits on molybdenum does not.

The emission from thin films of thorium deposited on to titanium and tungsten has also been studied. The emission from a layer on titanium that had been thoroughly pre-cleaned was found to be much less than that from a similar layer on tungsten.

The application of these results to the suppression of grid emission in the presence of thoriated tungsten cathodes in transmitting valves is discussed.

Method for measuring the complex dielectric constant of a high-loss liquid at 8 mm wavelength. By E. H. Grant.

A method specifically suited to the investigation of liquids exhibiting high dielectric constant and high loss at 8mm wavelength is described. Conventional techniques for measuring wavelength in the liquid and attenuation coefficient have been adapted for this purpose, and a feature of the method is the use of the same experimental cell for both reflexion and absorption measurements. The measured value for the complex dielectric constant of water at 25°C is in close agreement with theory.

Linear photomultiplier bridge circuit for the measurement of small changes in absorption. By P. Hariharan, A.Inst.P., and M. S. Bhalla.

In the circuit described, the voltage applied to the two photomultipliers is controlled by means of a negative feedback loop so that the anode current of the monitor photomultiplier is held approximately constant. The ratio of the anode currents of the two photomultipliers is then linearly proportional to the transmission of the sample and is unaffected by fluctuations in the luminous output of the source and variations in the mains voltage. In addition, the sensitivity of the bridge remains constant, so that it is possible to estimate small changes in absorption directly from readings of the out of balance current.

Deposition by thermal evaporation of thin films of titanium and zirconium for tritium targets. By V. D. Scott and L. W. Owen.

Equipment and procedure are described for applying thin films of titanium and zirconium as tritium carriers to backings of copper, gold and platinum. A large proportion of the coatings prepared absorbed high atom ratios of tritium, titanium being more satisfactory in this respect than zirconium. It is suggested that defects in the coating arise mainly from the undesirable reaction of the metals with residual gases, particularly oxygen, during evaporation in the vacuum chamber. Firstly, this causes stress, brittleness, and owing to lack of adhesion, blistering of the deposit ; secondly absorption of tritium is inhibited by the oxide film on the metal surface, and the total amount absorbed reduced as a result of there being fewer lattice sites available for the tritium. An electron diffraction examination showed that although the deposits appeared bright and metallic, a thin protective oxide film was present on the evaporated titanium and zirconium.

Experimental determination of the atomizing efficiency of a high-speed spinning disk atomizer. By D. J. Ryley.

Electrically driven disks of 3 and 5 cm diameter were rotated at speeds 20,000-60,000 rev/min, and samples of an aqueous spray were analysed for flow rates of 0·12, 0·42 and 0·77 cm^3/s. The reduction in disk speed during atomizing was determined experimentally using an electronic pulse counter and a miniature dynamometer was devised to simulate this reduction and measure the power consumed. Atomizing efficiencies for the electrically driven disk thus obtained are compared briefly with the efficiency employing air drive and also with that of a simple pressure atomizer. In all cases efficiencies are less than 0·5%.

Distribution of relaxation times in a symmetrically stressed renneted milk gel. By G. W. Scott Blair, F.Inst.P., and J. Burnett.

Applying the graphical method of the " Central Limit Theorem." it is found that repeated relaxation experiments on suitably prepared renneted milk gels indicate a log-normal distribution of relaxation times, under optimal temperature conditions. This depends on minimizing strain-stiffening by alternating the direction of the stresses and also on the use of a particular convention for fixing the time zero. The disparity between the immediate elastic displacement of these gels under load and the immediate part of their recovery, previously ascribed to a type of thixotropy, is now explained in terms of static fatigue.

Volume of drops of aqueous solutions transferred to a slide by a " micro-rod." By A. E. Hawkins, A.Inst.P.

It is shown that it is possible to estimate the volume of aqueous solution transferred by a " micro-rod " from a liquid surface to a clean glass surface. It is also shown that if several aqueous solutions are transferred it is possible to estimate the relative proportions of the solutions comprising the mixture on the glass surface.

Insurances for Physicists

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ENGLISH ELECTRIC VALVE COMPANY LTD.

CHELMSFORD, ESSEX

Engineers and physicists are required at the Company's Works in Chelmsford for the following departments.

Large Valve	Camera Tube
Magnetron	Klystron
Semi-conductor	Research

There are positions in development and production associated with these departments and salaries will be determined by experience and qualifications. Applications are invited from men with a degree in Physics or Electrical Engineering and postgraduate training experience in the valve industry. Applicants with H.N.C. in physics, electrical or mechanical engineering will also be considered provided they have three years' experience in either design, development or production in the valve industry.

Applications should be addressed to Dept. C.P.S., Marconi House, The Strand, W.C.2, quoting reference PB 1506V.

ESSEX COLLEGE
ASSUMPTION UNIVERSITY OF WINDSOR, WINDSOR, ONTARIO

Applications are invited for the appointment of the HEAD OF THE DEPARTMENT OF PHYSICS. The position would involve the administration of undergraduate and graduate activities in the department which participates in honours chemistry and physics, mathematics and physics, and engineering physics programs. A course leading to the M.Sc. degree in physics has just been inaugurated. There are generous provisions for research, and a new physics building is being planned. The salary will be in the range of $8,500-$14,500. A contributory pension scheme is in existence. Enquiries should be addressed to the Chairman of the Staff Committee, Essex College, Assumption University of Windsor, Windsor, Ontario, Canada.

McMASTER UNIVERSITY
HAMILTON, CANADA

THEORETICAL PHYSICS

The Department of Physics, McMaster University, has an opening for an additional theoretical physicist with a research interest in solid state physics. Salary and rank will depend upon the qualifications of the appointee, but the minimum annual stipend will be at least $7,040. Further information concerning this opening may be had from the Chairman of the Department of Physics or from Dr. M. A. Preston.

ENGLISH ELECTRIC VALVE COMPANY LTD.

CHELMSFORD, ESSEX

Fundamental Research in Photoconductivity, and allied fields

Applications for the above post are invited from physicists with a higher degree or a good honours degree. Preference will be given to candidates with research experience in photoconductivity or in other branches of solid state physics or semi-conductors.

Starting salary will take into account relevant experience.

Applications should be sent to Dept. C.P.S., Marconi House, The Strand, W.C.2, quoting reference PB 1513B.

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We have vacancies in our new development laboratory for

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Acitivities include the development of new silicon transistors and rectifiers, and of new high-frequency germanium transistors.

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Non-contributory schemes for Pension, Life Insurance and Hospital Benefits.

Write, giving brief chronological details, which will be treated in confidence to—

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Northumberland

RESEARCH PHYSICIST is required by a company engaged in the development of a wide variety of components used by the electronic industry. Well-equipped laboratories exist and an increasing program of basic research and interesting development is in hand. This appointment will provide an opportunity for a qualified candidate to establish himself in a vital and rapidly expanding field in which interest in many branches of physics may be satisfied.
Clearly defined salary scales exist and it is intended that the successfull applicant be placed on a scale in the range £800 – £1,200 per annum with minimum annual increments of £50.
An invitation to inspect the laboratories and to ascertain the amenities provided will be extended to selected candidates who provide full details of their career and qualifications to the Personnel Manager.

McMASTER UNIVERSITY

POST-DOCTORAL FELLOWSHIPS IN PHYSICS

Applications are invited for National Research Council and other Post-Doctoral Fellowships tenable in the Department of Physics, McMaster University. Successful applicants may choose to work full-time on their research or to supplement their research with a modest amount of lecturing.
Inquiries and applications should be addressed to Professor H. E. Duckworth, Chairman, Department of Physics, McMaster University, Hamilton, Ontario, Canada.

McMASTER UNIVERSITY

GRADUATE SCHOLARSHIPS IN PHYSICS

Applications are invited for Graduate Scholarships in the Department of Physics, McMaster University, from students qualified to register in courses leading to the M.Sc. and Ph.D. degrees. These scholarships may be supplemented by departmental assistantships, requiring ten hours per week service during the seven-month academic year, to provide a yearly income of $1,700 – $2,100.
Theoretical and experimental research is in progress in several branches of nuclear and solid state physics.
Graduate Calendars and application forms for graduate study may be obtained from the Secretary of the Faculty of Graduate Studies. Further information concerning the types of research in progress and application forms for scholarships may be obtained from Professor H. E. Duckworth, Department of Physics, Hamilton College, McMaster University, Hamilton, Ontario, Canada.

VICTORIA UNIVERSITY OF WELLINGTON
NEW ZEALAND

SENIOR LECTURER IN PHYSICS

Applications are invited for the above post.
The salary will be £1,315 per annum, rising by annual increments of £50 to £1,615. The initial salary will be determined according to the qualifications and experience of the appointee. An allowance is made towards travelling expenses.
Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1.
Applications close, in New Zealand and London, on March 31, 1959.

THE COLLEGE OF AERONAUTICS

Applications are invited from candidates with suitable academic qualifications and experience for the following appointments in the Department of Aircraft Materials:

LECTURER in Non-Metallic Materials. Candidates should have a good background in physics with experience of research as supervision of student thesis work is involved. Excellent facilities exist for personal research. Salary in scale £900 × £50 to £1,350 × £75 to £1,650 p.a., with superannuation under F.S.S.U. and family allowance.

DEMONSTRATOR in Physical or Industrial Metallurgy, to assist in the laboratory teaching and research work. Salary in scale £600 × £25 to £1,000 p.a. with superannuation under F.S.S.U. and family allowance. Subsequent promotion to Lecturer is possible if suitably qualified.

RESEARCH FELLOW in Physical Metallurgy or Metal Physics, to work in the field of deformation and dynamic stressing. Considerable research facilities exist and the successful candidate will be free to choose any line of study related to the interests of the college. Previous research experience is essential. Salary in range £650 to £900 p.a. (Research Fellowship) or £1,000 to £1,200 p.a. (Senior Research Fellowship) with superannuation under F.S.S.U. and family allowance.

LABORATORY ENGINEER, to be responsible for technical equipment in the Department, and the design and construction of research apparatus, and to advise generally on technical development. Salary in scale £700 × £25 to £850 × £25 to £1,000 p.a., with Local Government Superannuation.

In all cases the commencing salary within the prescribed scale will depend upon age, qualifications and experience. Consideration will be given to candidates' housing requirements. Applications giving full particulars and the names of three referees should be forwarded to the Recorder, The College of Aeronautics, Cranfield, Bletchley, Bucks. Further particulars available.

HIGH POLYMER RESEARCH

The British Rayon Research Association requires a PHYSICIST to undertake original research in the field of mechanical properties of high polymers. First or second class honours degree in physics essential. Commencing salary in the range £650 – £1,100, according to age and qualifications. The laboratories are on the fringes of rural Cheshire, within easy reach of pleasant residential districts. Assistance may be given with accommodation. Apply to the Secretary, British Rayon Research Association, Heald Green Laboratories, Wythenshawe, Manchester 22, quoting ref. P.5.

THE UNIVERSITY OF SOUTHAMPTON
DEPARTMENT OF PHYSICS

Applications are invited for the post of LECTURER IN PHYSICS. Salary Scales: Lecturer £900 × £50 – £1,350 × £75 – £1,650 with an efficiency bar at £1,300. Assistant Lecturer £700 × £50 – £850. The initial salary will depend on qualifications and experience. Further particulars should be obtained from the Secretary and Registrar to whom applications (7 copies from United Kingdom applicants, 1 copy from others) should be sent not later than March 4, 1959.

PHYSICISTS

DUNLOP RESEARCH CENTRE

desire to make the following appointments of graduate Physicists :

PHYSICAL RESEARCH DEPARTMENT

Three appointments for research into the physical properties of high polymers. In the first instance the work will be concerned with:

(1) *The frictional properties of rubber and associated polymers.*

(2) *Electrical and dielectric phenomena of rubber and associated polymers.*

(3) *The dependance of physical properties of natural and synthetic rubbers upon their molecular structures.*

COMPOUNDING RESEARCH DEPARTMENT

An appointment involving the development of testing methods for vulcanized rubbers; including new methods and equipment, as well as the improvement of existing systems.

These appointments offer excellent opportunities for original work, and, whilst previous experience would be valuable, it is not essential. Please reply, giving brief details of qualifications and experience to

PERSONNEL MANAGER
DUNLOP RESEARCH CENTRE, ERDINGTON
BIRMINGHAM, 24

Reference J.M.163. should be quoted when replying.

ESSEX COLLEGE
ASSUMPTION UNIVERSITY OF WINDSOR, WINDSOR, ONTARIO

The Department of Physics offers GRADUATE ASSISTANTSHIPS to candidates wishing to proceed to an M.Sc. in physics. Stipend up to $2,000 for eight months, depending on qualifications and duties in the Department. There is a possibility of additional income during the summer months. Enquiries should be addressed to the Head of the Department of Physics, Essex College, Assumption University of Windsor, Windsor, Ontario, Canada.

BIRKBECK COLLEGE
(UNIVERSITY OF LONDON)

RESEARCH ASSISTANT required in the Department of Physics for postgraduate studies in electron diffraction and microscopy leading if desired to a higher degree. The duties, which will include responsibility for installing new equipment (Metro-Vick electron microscope Type EM6), are concerned mainly with research into the structure of inorganic substances. Preliminary training will be arranged but previous experience, preferably of electron diffraction work, is desirable. Salary on the scale of £750 × £50 – £900. Further particulars should be obtained without delay from the Secretary, Birkbeck College, Malet Street, W.C.1.

BICC

PHYSICIST OR ELECTRICAL ENGINEER, graduate, preferably of honours degree standard required for the Shepherds Bush research laboratories of British Insulated Callender's Cable Limited. The work involves research and development on dielectrics and capacitors. Previous experience in this field would be desirable but is not essential. Five-day week ; pension fund. Applications giving details of age, qualifications and experience to be made to Personnel Officer, BICC Ltd., 38 Wood Lane, London, W.12.

UNIVERSITY OF BIRMINGHAM
DEPARTMENT OF CIVIL ENGINEERING

As a result of the expansion of the department, applications are invited for LECTURESHIPS in civil engineering. Salary within the range £900 to £1,650 according to qualifications and experience.

Applicants should satisfy one of the following requirements :

(*a*) Have specialized knowledge of fluid mechanics, possibly, but not necessarily, having undertaken a postgraduate course. They should possess a good honours degree in engineering and be interested in research and laboratory development.

(*b*) Have general civil engineering experience and should have an interest in soil mechanics, highway or foundation engineering and should possess a good honours degree in civil engineering.

(*c*) Have specialized knowledge of theoretical and applied elasticity or fluid mechanics and should possess a good honours degree in applied mathematics or engineering science ; research experience is very desirable.

(*d*) Have a knowledge of surveying, including geodetic survey and photogrammetry, and be a university graduate and preferably a member of a professional institution.

For each of these appointments time and facilities would be available for research work. The Lecturers will be required to take up their duties as soon as possible.

Applications (two copies), with the names of three referees, should be sent by March 1, 1959, to the Deputy Registrar, The University, Birmingham, 15, from whom further particulars may be obtained.

UNIVERSITY OF BIRMINGHAM
DEPARTMENT OF CIVIL ENGINEERING

Applications are invited for a RESEARCH FELLOWSHIP in the department of civil engineering.

The program, on which the successful applicant would be engaged, concerns the use of electrolytic tanks for the solution of aerodynamic and hydraulic problems in fluid motion.

Applicants should have at least a good honours degree in physics or engineering, with some previous research experience. Salary £700 × £50 to £800 p.a. ; the appointment to commence as soon as possible.

Applications (two copies), with the names of two referees, should be sent before April 1, 1959, to the Deputy Registrar, The University, Birmingham, 15, from whom further particulars may be obtained.

RESEARCH PHYSICIST

UNILEVER REQUIRE A PHYSICS GRADUATE to work at one of their research centres. The person appointed should preferably have some experience of microwave techniques and be prepared to work on the application of physics to biological problems. A progressive salary will be paid and starting salary will depend on age and experience. There is a comprehensive superannuation scheme.

Apply initially to : Personnel Division, Unilever Limited, Unilever House, Blackfriars, London, E.C.4.

THE UNIVERSITY OF LEEDS
DEPARTMENT OF PHYSICS

Applications are invited for appointments in the Department of Physics as LECTURER or ASSISTANT LECTURER at salaries on the scale £900 × £50–£1,350 (efficiency bar) × £75–£1,650 for a Lecturer, or within the range £700–£850 for an Assistant Lecturer, according to age, qualifications and experience. If suitable candidates are available, more than one appointment will be made. Applications (three copies) stating date of birth, qualifications and experience, together with the names of three referees, should reach the Registrar, The University, Leeds, 2 (from whom further particulars may be obtained) not later than March 21, 1959.

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